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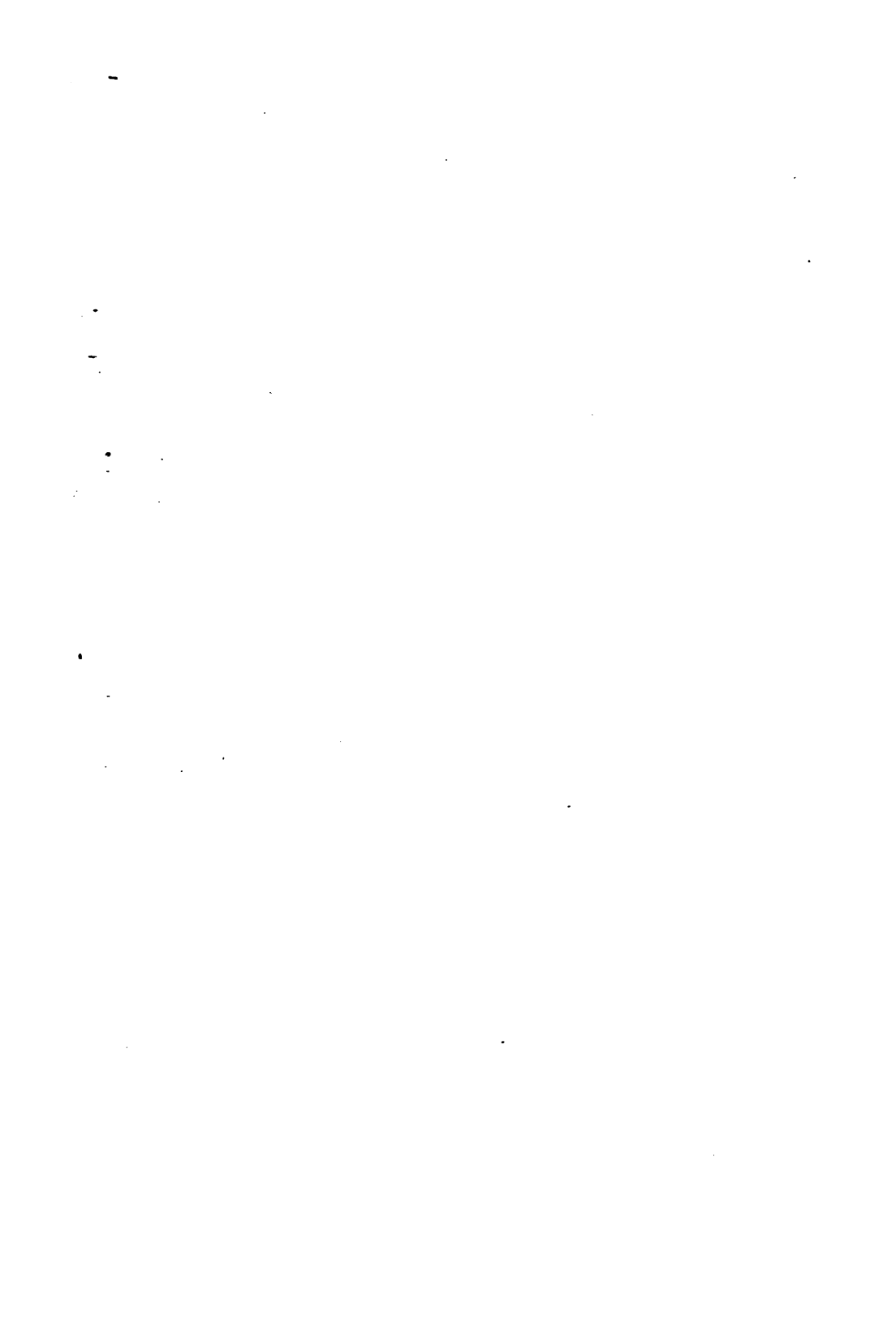
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## PREFACE

THE authors of this text-book have endeavored to furnish the student of nursing in concise form a simple and clear presentation of those portions of the sciences—physics and chemistry—which are of special interest and importance to the student and the graduate nurse.

The work is necessarily brief. The curricula of most schools of nursing call for but one year of instruction in physics and chemistry. The authors therefore decided to discuss only the amount of material which, in their opinion, could be intelligently digested by the average studious nurse in the time allotted to the subjects.

The authors will welcome any suggestions looking to the improvement of the text-book.

Thanks are due to the following authorities whose works were frequently consulted and proved of great value in the preparation of this book: Allen, Autenrieth, Barmwater, Bartley, Beal, Brundage, Bunge, Coblentz, Doremus, Everett, Glazebrook, Hill, Holland, Hoadley, Krafft, Lassar-Cohn, Leach, Long, Molinari, Morgan, Mason, Novy, Prudden, Remsen, Rottget, Remington, Sadtler, Simon, Stewart, Thoms, Tyrode, the United States Pharmacopœia, Vaughan, Voit, Witthaus, and Wood; also to Miss Ellison, of the Cincinnati General Hospital, formerly Principal of the Hillman Hospital Training School for Nurses, and Miss Dugan, Principal of the Hillman Hospital Training School for Nurses, for valuable suggestions and criticisms. Thanks are especially due to Eimer and Amend, of New York City, for the use of their half-tones.

BIRMINGHAM, ALABAMA,  
January, 1916.

A. R. B., JR.  
A. H. O.





# CONTENTS

## PART I

### ELEMENTARY PHYSICS

#### CHAPTER I

<b>MATTER AND ITS PROPERTIES.....</b>	<b>PAGE 3</b>
General Definitions: Matter—Science—Physics—Extension—Volume—Mass—Divisibility—Atom—Molecule—Indestructibility—States of Matter—Impenetrability—Porosity—Compressibility—Elasticity—Force—Energy—Work—Gravitation—Weight—Specific Gravity—Hydrometers.	
Special Properties of Solids: Hardness—Brittleness—Tenacity—Malleability—Ductility—Crystals—Regular System—Tetragonal System—Rhombic System—Monoclinic System—Triclinic System—Hexagonal System.	
Special Properties of Liquids: Capillary Phenomena—Cohesion—Adhesion—Diffusion—Colloids—Crystalloids—Solution—Filtration—Maceration—Digestion—Infusion—Decoction—Percolation.	
Gases: Diffusion—Atmosphere—Barometer—Siphon.	

#### CHAPTER II

<b>HEAT AND LIGHT.....</b>	<b>14</b>
Heat—Thermometer—Calorimetry—Fusion—Ignition—Calcination—Deflagration—Incineration—Carbonization—Torrefaction—Vaporization—Evaporation—Distillation—Sublimation—Desiccation—Exsiccation.	
Light: Mirrors—Images—Refraction—Prism—Lenses—Color—Prismatic Spectrum—Camera—The Eye.	

#### CHAPTER III

<b>MAGNETISM AND ELECTRICITY.....</b>	<b>24</b>
Lodestone—Magnets—Mariner's Compass.	
Electricity: Frictional—Inductive—Chemical—Galvanic Cell—Conductors—Non-conductors—Battery—Volt—Ampère—Ohm—Watt—Thermal Electricity—Cathode Ray—X-rays—Röntgen Rays—Electric Arc—Incandescent Light.	

#### CHAPTER IV

<b>ACOUSTICS.....</b>	<b>29</b>
Definition: Vibrations—Transmission—Echo—Resonance—The Ear—Musical Sound.	

## PART II

## INORGANIC CHEMISTRY

## CHAPTER V

## CHEMICAL PHILOSOPHY..... 33

Physical Changes—Chemical Changes—Mechanical Mixtures—Chemical Compounds—Reactions—Synthetic Reactions—Analytic Reactions—Chemical Affinity—Chemistry—Elements—Chemical Symbols—Table of Elements—Chemical Formula—Atomic Weight—Molecular Weight—Valence—Valence Table—Chemical Equations—Radical.

Acids—Bases—Neutralization—Salts—Normal or Neutral Salts—Acid Salts—Double Salts—Basic Salts—Radicals—Ionization—Cations—Anions—Electrolysis—Chemical Nomenclature—Oxidation and Reduction.

## CHAPTER VI

## THE METALS..... 47

Definition—Sources—Extraction—Physical Properties—Chemical Properties—Effects of the Atmosphere—Chemical Combination—Uses—Alloys—Amalgams—Physiological Effects—Salts—Radium, etc.

## CHAPTER VII

## THE NON-METALS..... 51

Hydrogen—Oxygen—Combustion—Oxidation—Ozone—The Halogens—Chlorine—Bromine—Iodine—Fluorine.

Nitrogen—The Atmosphere—Sulphur—Phosphorus—Boron—Silicon—Carbon—Graphite—Diamond.

## INORGANIC COMPOUNDS

## CHAPTER VIII

## ACIDS..... 62

Definition—The Halogen Acids: Hydrochloric Acid—Hydrobromic Acid—Hydriodic Acid—Hydrofluoric Acid.

The Sulphur Acids: Sulphurous Acid—Sulphuric Acid—Hydrosulphuric Acid.

The Nitrogen Acids: Nitrous Acid—Nitric Acid—Nitrohydrochloric Acid.

The Phosphorus Acids: Phosphoric Acid—Hypophosphorous Acid.

The Arsenic Acids: Arsenous Acid—Arsenic Acid.

Hydrocyanic Acid.

Carbonic Acid—Boric Acid.

## CONTENTS

vii

### CHAPTER IX

BASES.....	70
------------	----

Properties—Hydroxides—Alkalies—Potassium Hydroxide—Sodium Hydroxide—Ammonium Hydroxide—Calcium Hydroxide—Magnesium Hydroxide—Ferric Hydroxide.

### CHAPTER X

SALTS.....	74
------------	----

Definition—The Halogen Salts. *Chlorides*: Sodium Chloride—Potassium Chloride—Ammonium Chloride—Mercurous Chloride—Mercuric Chloride. *Chlorates*: Potassium Chlorate—Sodium Chlorate. *Hypochlorites*: Sodium Hypochlorite—Potassium Hypochlorite—Calcium Hypochlorite. *Bromides*: Sodium Bromide—Potassium Bromide—Ammonium Bromide—Calcium Bromide—Lithium Bromide—Strontium Bromide—Zinc Bromide—"Bromism." *Iodides*: Sodium Iodide—Potassium Iodide—Ammonium Iodide—Mercurous Iodide—Mercuric Iodide—Ferrous Iodide—Arsenous Iodide—Bismuth Oxyiodide—Uses of the Iodides—"Iodism."

Sulpho-Salts: *Sulphites*: Sodium Sulphite, Sodium Bisulphite and Calcium Sulphite. *Sulphates*: Magnesium Sulphate—Sodium Sulphate—Ferrous Sulphate—Copper Sulphate—Aluminium Sulphate—Potassium Aluminium Sulphate—Zinc Sulphate—Calcium Sulphate. *Sulphides*: Calcium Sulphide—Carbon Disulphide. *Thiosulphates*: Sodium Thiosulphate.

Nitro-Salts: *Nitrates*: Sodium Nitrate—Potassium Nitrate—Silver Nitrate—Bismuth Subnitrate—Mercuric Nitrate.

Phospho-Salts: *Phosphates*: Sodium Phosphate—Calcium Phosphate—Ferric Phosphate. *Pyrophosphates*: Ferric Pyrophosphate—Sodium Pyrophosphate. *Hypophosphites*: Sodium, Potassium, Ferric, Manganese, and Calcium Hypophosphites.

*Carbonates*: Sodium Carbonate—Potassium Carbonate—Ammonium Carbonate—Ferrous Carbonate—Magnesium Carbonate—Lithium Carbonate—Calcium Carbonate—Zinc Carbonate.

*Bicarbonates*: Sodium Bicarbonate—Potassium Bicarbonate.

*Borates*: Sodium Borate. *Arsenites* and *Arsenates*: Potassium Arsenite—Sodium Arsenate—Paris Green—Scheele's Green.

*Permanganates*: Potassium Permanganate. *Cyanides*: Potassium Cyanide.

## OXIDES

### CHAPTER IX

NON-METALLIC OXIDES.....	91
--------------------------	----

Oxides of Hydrogen—*Water*—Hardness—Water of Crystallization—Efflorescence—Hygroscopic Compounds—Deliquescence—Rain Water—Potable Water—Distilled Water—Mineral Water—Carbonated Waters—Sulphur Waters—Alkaline Waters—Lithia Waters—Saline Waters—Chalybeate Waters—Sea-water—*Hydrogen Dioxide*—*Sulphur Dioxide*—*Nitrogen Monoxide*—*Carbon Monoxide*—*Carbon Dioxide*.

## CHAPTER XII

METALLIC OXIDES.....	96
----------------------	----

*Calcium Oxide—Lead Oxide—Magnesium Oxide—Mercuric Oxide—Yellow Mercuric Oxide—Red Mercuric Oxide—Zinc Oxide—Arsenic Trioxide.*

## PART III

## ORGANIC CHEMISTRY

## CHAPTER XIII

THE COMPOUNDS OF CARBON.....	101
------------------------------	-----

The Terms "Organic" and "Inorganic"—Elements Contained in Organic Compounds—Test for Carbon—Test for Hydrogen—Test for Nitrogen—Test for Sulphur—Test for Phosphorus—"Chain Series"—"Open-chain Series"—"Closed Chain."

## CHAPTER XIV

HYDROCARBONS.....	104
-------------------	-----

Definition—Classification.

The Paraffins or Fatty Series—*Methane—Petroleum—Benzin—Naphtha—Gasolene—Kerosene—Petrolatum—Paraffin.*

The Olefins and Acetylenes: The Terpenes. Volatile Oils: *Oil of Turpentine—Rectified Oil of Turpentine—Other Oils Used in Medicine—Menthol—Thymol—Eucalyptol.*

The Benzenes: *Benzene—Toluene—Xylene—Cumene—Naphthalene.*

## CHAPTER XV

DERIVATIVES OF THE HYDROCARBONS.....	110
--------------------------------------	-----

Halogen Salts: *Methyl Chloride—Ethyl Chloride—Chloroform—Ethyl Bromide—Bromoform—Iodoform.*

Alcohols: Definition—Classification—*Methyl Alcohol—Ethyl Alcohol—Alcohol, U. S. P.—Absolute Alcohol, U. S. P.—Diluted Alcohol, U. S. P.—Denatured Alcohol—Whiskey—Brandy—Gin—White Wine—Red Wine—Sparkling Wines—Still Wines—Dry Wines—Sweet Wines—Glycerin.*

Ethers and Esters: Definitions—*Ether—Ethyl Ether—Methyl Salicylate—Nitrous Ether—Nitroglycerin—Amyl Nitrite—Phenyl Salicylate—Fats and Oils—Vegetable Oils—Animal Oils—Animal Fats and Waxes—Oleomargarine and Butterine—Soaps.*

Aldehydes: Definition—*Formaldehyde—Methyl Aldehyde—Paraldehyde—Chloral—Chloral Hydrate—Benzaldehyde.*

Ketones: Definition—*Acetone.*

## CONTENTS

ix

### CHAPTER XVI

#### DERIVATIVES OF THE HYDROCARBONS (*Continued*) ..... 122

Organic Acids: *Formic Acid—Acetic Acid—Trichloroacetic Acid—Butyric Acid—Lactic Acid—Oxalic Acid—Tartaric Acid—Citric Acid—Benzoic Acid—Salicylic Acid—Tannic Acid—Gallic Acid—Acetylsalicylic Acid.*

Organic Salts: *Acetates:* Potassium, Sodium, Lead, Zinc—Uses. *Tartrates:* Potassium Acid Tartrate—Potassium and Sodium Tartrate—Antimony and Potassium Tartrate. *Citrates:* Potassium, Sodium, Lithium, Bismuth—Uses. *Benzoates:* Ammonium, Lithium, Sodium—Uses. *Salicylates:* Ammonium, Lithium, Sodium, Strontium, Bismuth (Sub-salicylate)—Mercury Salicylate (Basic)—Uses.

Phenols: Definition—*Phenol—Cresol—Creosote—Resorcinol.*

Sulphur Derivatives: *Sulphonmethane—Sulphonethylmethane—Tetronal.*

Compounds Containing Nitrogen: *Hexamethylenamine—Carbamid—Diethyl-malonyl-urea.*

Derivatives of Benzene: *Acetanilid—Acetphenetidin—Trinitrophenol—Antipyrine—Paradiamidodioxarsenobenzol Hydrochloride.*

### CHAPTER XVII

#### CARBOHYDRATES..... 135

Definition—Classification—Monosaccharides or Simple Sugars—Disaccharides or Complex Sugars—Polysaccharides—*Dextrose, Grape-sugar, Glucose—Sucrose, Cane-sugar—Saccharum—Lactose, Sugar of Milk—Starch—Cellulose—Parchment Paper—Mercerized Cotton—Absorbent Cotton—Medicated Cotton—Artificial Silk—Pyroxylin—Wood Silk—Celluloid—Collodion—Flexible, Styptic and Cantharidal Collodions—Glycogen.*

*Glucosides—Amygdalin, Absinthin, Digitalin, Indican, Glycyrrhizin, Frangulin, Jalapin—Myronic Acid—Salicin—Santonin—Saponin—Strophanthin.*

### CHAPTER XVIII

#### ALKALOIDS AND PTOMAINES..... 140

Alkaloids: Definition—*Pilocarpine—Nicotine—Atropine—Hyoscyamine—Cocaine—Quinine—Cinchonine—Strychnine—Morphine—Opium—Codeine—Apomorphine Hydrochloride—Dionin—Heroin—Physostigmine—Aconitine—Veratrine—Hydrastine—Coniine—Sparteine—Caffeine.*

Ptomaines: Definition—*Isoamylamine—Cadaverine—Neurine—Telanine—Tyrotoxicon.*

## PART IV

### PHYSIOLOGICAL CHEMISTRY

#### CHAPTER XIX

#### PROTEINS..... 149

Definition—Analyses—Classification. Tests: Heat Test—Heller's Test—Xanthoproteic Test—Biuret Test—Lieberman's Test.

## CHAPTER XX

## FOODSTUFFS ..... 151

Classification—Foodstuff Table—Milk—Analysis of Woman's and Cow's Milk—Meat—Bread—The Cooking of Foodstuffs—Objects of Cooking—Green Vegetables—Table of Calorific Values.

## CHAPTER XXI

## DIGESTION ..... 155

Definition—*Salivary Digestion*—Saliva—Ptyalin—Gastric Digestion—Gastric Juice—Composition of Gastric Juice—Pepsin—Renin—Peptones—*Intestinal Digestion*—Pancreatic Juice—Bile—*Succus Entericus*—*Absorption*.

## CHAPTER XXII

## THE CHEMICAL COMPOSITION OF THE HUMAN BODY ..... 157

Elements in the Human Body—Table of Elements—The Compounds in the Human Body: *Water*—*Hydrogen Dioxide*—*Carbon Dioxide*—*Hydrogen Sulphide*—*Ammonia*—*Methane*—*Chlorides*—*Calcium Fluoride*—*Phosphates*—*Carbonates*—*Sulphates*—*Silica*—*Dextrose*—*Lactose*—*Glycogen*—*Inosit*—*Fat*—*Lecithin*—*Protagon*—*Cerebrin*—*Formic Acid*—*Acetic Acid*—*Diacetic Acid*—*Beta-oxybutyric Acid*—*Propionic Acid*—*Butyric Acid*—*Oxalic Acid*—*Isovaleric Acid*—*Capric Acid*—*Stearic, Oleic and Palmitic Acids*—*Lactic Acid*—*Sarcos-lactic Acid*—*Uric Acid*—*Fellic Acid*—*Cholic and Choleic Acids*—*Acetone*—*Phenol*—*Indol*—*Skatol*—*Creatine*—*Creatinine*—*Tyrosine*—*Leucine*—*Glycocol*—*Urea*—*Choline*—*Neurine*—*Taurine*—*Cholesterolin*—*Bilirubin*—*Biliverdin*—*Melanins*.

Experiments: Tests for the More Common Metals: Potassium—Sodium—Lithium—Ammonium—Calcium—Magnesium—Iron—Manganese.

Tests for the More Common Acids: Hydrochloric—Sulphuric—Phosphoric—Carbonic—Hydrosulphuric—Nitric—Oxalic—Hydriodic—Hydrobromic—Boric.

Composition of Bone—Composition of Bone Earth—Tests on Bone.

Saliva: Definition—Composition—Tests on Saliva.

Blood—Sweat.

## CHAPTER XXIII

## URINE AND URINALYSIS ..... 169

Definition—Properties—Chemical Analysis—Collection of Urine—Examination—Examination for Inorganic Matter—Determination of Urea—Test for Uric Acid.

Abnormal Constituents: Albumin—Dextrose—Fehling's Solution—Fehling's Test—Acetone—Excessive Urea and Uric Acid—Excessive Indican—Blood—Bile.

PART V

FERMENTATION AND FERMENTS

DISINFECTANTS, DEODORANTS AND ANTISEPTICS

CHAPTER XXIV

FERMENTATION AND FERMENTS..... 177

Definitions: Fermentation—Enzymes. *Making of Bread:* Dough—Gluten—Yeast—Black Bread—White Bread—Baking Powders—Juice of Grapes—*Wine*—Cider and Perry—Champagne. *Beer:* Definition—Lager Beer—Bock Beer—Ale—Porter—Stout—Malting—Brewing—Diastase—Wort—Whiskey—Mash—Artificial Whiskey—Alcohol—Brandy—Rum—Gin—Koumis.

Ferments: Classification: I. Unorganized Ferments or Enzymes—Classification of Enzymes. Vegetable Enzymes: *Diastase—Lactase—Maltase—Cellulase—Inulase—Saccharase—Pectinase—Emulsin—Papain—Invertin—Bromelin—Zymase.* Animal Enzymes *Pepsin—Trypsin—Erepsin—Ptyalin—Amylopsin—Invertase—Pancreatin—Steapsin—Rennin—Chymase—Histozy.*

II. Organized or Living Ferments: *Yeast—Dry Yeast—Top Yeast—Bottom Yeast—Compressed Yeast—Mycoderma Aceti—Bacilli Lacti—Bacilli Butyrici—Micrococci Ureae—Mucor Mucedo—Oidium Albicans—Nitrifying Ferments—Pathogenic Microorganisms.*

CHAPTER XXV

DISINFECTANTS, DEODORANTS AND ANTISEPTICS..... 188

Definitions—Disinfectant or Germicide—Deodorant—Antiseptic—Antizymotic.

*Heat—Moist and Dry Heat—Phenol—Mercuric Chloride—Mercuric Cyanide—Potassium Permanganate—Formaldehyde—Hydrogen Dioxide—Silver Nitrate—Iodoform—Creosote—Cresol—Hexamethylenamine—Glycerin.* The Halogens: *Chlorine—Bromine—Iodine—Fluorine—Oxygen—Soap—Alcohol.* Acids: *Mineral Acids—Sulphurous Acid—Boric Acid—Acetic Acid—Benzoic Acid—Salicylic Acid—Lactic Acid—Tartaric and Citric Acids—Tannic Acid—Chloroform—Ether—Lime and Slaked Lime—Zinc Phenolsulphonate—Copper Sulphate—Ferrous Sulphate—Chromium Trioxide—Volatile Oils and Stearoptens—Quinine—Chloral Hydrate—Acetanilid—Resorcin—Petroleum—Naphthalene.*

APPENDIX

WEIGHTS AND MEASURES..... 209

Troy Weight—Apothecaries' Weight—Avoirdupois Weight—Apothecaries' or Wine Measure (U. S.)—Imperial Measure—Approximate Measures—The Metric System—Equivalents.

GLOSSARY..... 212

PERCENTAGE SOLUTION TABLE..... 224

INDEX ..... 225





# ILLUSTRATIONS

FIG.	PAGE
1.—HYDROMETERS.....	5
2.—THE SIX SYSTEMS OF CRYSTALLIZATION.....	7
3.—CAPILLARY PHENOMENA.....	8
4.—DIALYZERS.....	9
5.—HOT-WATER FUNNEL.....	9
6.—BERKEFELD HOUSE FILTER.....	9
7.—TINCTURE PRESS.....	10
8.—PERCOLATORS.....	10
9.—A BAROMETER.....	12
10.—SIPHON BAROMETER.....	12
11.—U. S. SIGNAL SERVICE BAROMETER.....	12
12.—SIPHON.....	13
13.—SECTION OF ATWATER CALORIMETER.....	16
14.—PORCELAIN CRUCIBLE AND COVER.....	16
15.—COPPER WATER-BATHS.....	17
16.—PARTS OF DISTILLATION APPARATUS.....	18
17.—STOKES AUTOMATIC WATER STILL.....	18
18.—BARNSTEAD HOME STILL... ..	18
19.—DISTILLING APPARATUS.....	19
20.—REFLECTION OF LIGHT RAYS BY A MIRROR.....	20
21.—REFRACTION OF A LIGHT RAY BY WATER.....	21
22.—REFRACTION OF A LIGHT RAY BY A PRISM.....	21
23.—LENSES.....	21
24.—CROSS-SECTION OF THE EYE.....	22
25.—A MICROSCOPE.....	22
26.—PRISMATIC SPECTRUM.....	23
27.—BAR MAGNET.....	24
28.—HORSESHOE MAGNET.....	24
29.—AN INDUCTION COIL.....	25
30.—A SIMPLE GALVANIC CELL.....	26
31.—"BUNSEN'S CELL".....	26
32.—"GRENET'S BATTERY" OR BICHROMATE CELL.....	26
33.—VOLTMETER FOR MEASURING STRENGTH OF ELECTRIC CURRENTS..	27
34.—A CROOKES TUBE, SHOWING REFLECTED "X-RAYS".....	27
35.—SOUND WAVE-MOTION.....	29
36.—APPARATUS FOR GENERATING HYDROGEN.....	52
37.—APPARATUS FOR GENERATING CHLORINE.....	55
38.—APPARATUS FOR MAKING IODINE.....	56



**PART I**  
**ELEMENTARY PHYSICS**



# A TEXT-BOOK OF PHYSICS AND CHEMISTRY FOR NURSES

## CHAPTER I

### MATTER AND ITS PROPERTIES

**Matter** is anything which has weight, or anything which has length, breadth and thickness, or anything which occupies space.

**Science** treats of matter, the changes matter may undergo, and the laws governing the same. Science applied to living matter is called **biology**.

**Physics** is that branch of science which treats of the forces and motion of matter, and its changes of form, state and place. It is not directly concerned with the changes in composition, which changes alter the identity of matter.

**Extension** is that property of matter by virtue of which it occupies space.

**Volume** is the amount of space occupied by a given portion of matter, and implies all three dimensions—length, breadth and thickness. Extension in one direction only is **length**; extension in two directions is called **area**.

**Mass** is the amount of matter contained in a body.

**Divisibility** is that property by virtue of which matter may be subdivided. There must be some limit to such subdivision. For example: We might take a piece of iron the size of a marble and break it up into very small pieces. These pieces in turn might be reduced to a very fine powder. The naked eye is unable to distinguish the minute particles that compose this powder,

but upon placing some of it under a microscope they become visible as separate and distinct pieces. If we imagine a continuation of this subdivision, we will finally reach a point at which further subdivision is impossible, and this smallest, indivisible particle of iron is called an **atom** of iron. An **atom** then is the smallest particle of an **element**<sup>1</sup> which can exist.

A group of two or more atoms is called a **molecule**.

**Indestructibility.**—No particle of matter can be destroyed or created. This is sometimes called "Lavoisier's Law of the Indestructibility of Matter."

**States of Matter.**—Three states are recognized, *solid*, *liquid* and *gaseous*.

**Impenetrability.**—No two bodies can occupy the same space at the same time.

**Porosity.**—Apparent exceptions to the foregoing statement exist, as when water is poured into a glass filled with sand, or when a nail is driven into a piece of wood. In these cases we must, however, take into consideration the fact that spaces, called "**pores**," exist between the particles composing matter.

**Compressibility.**—This property of matter is dependent upon porosity. By exerting pressure upon a body, such as a sponge, the particles composing it are forced closer together, thereby causing it to occupy less space.

**Elasticity** is that property by virtue of which a body, after undergoing compression, stretching, twisting or bending, tends to assume its original form.

**Force** is that manifestation of energy which, acting upon matter, changes or tends to change its position or shape.

**Energy** is capacity for work and is possessed by all matter because of its mass and rate of motion.

Energy applied in overcoming resistance is known as **work**, as when some article is lifted from the ground. Energy may be **potential** or **kinetic**. Potential energy is energy of position. A stone held in the hand above the earth has power to do work as it will fall if released. This is **potential energy**. The same stone in

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<sup>1</sup> See "Elements," page 35.

falling, because of the withdrawal of the hand, possesses capacity for work due to its motion. This is **kinetic** or energy of motion.

Energy of one kind may be converted into energy of the other kind. Thus: In the case of the stone, the potential energy due to position is converted to visible energy of motion or kinetic energy without loss. In the steam engine the potential energy of coal is converted by combustion to heat energy, which in turn is converted to energy of motion.

**Gravitation.**—Every particle of matter in the universe attracts every other particle, consequently all bodies attract each other. This mutual attraction is known as **gravitation**. A measurement of the mutual attraction between the earth and a body is known as **weight**. Various systems of weighing are used. That known as the *Metric System* is the one used for scientific purposes.

The **specific gravity** or **specific weight** of a substance is its weight as compared with the weight of an equal volume of a standard substance taken as unity (1). The standard for liquids and solids is distilled water at 4° C.; for gases, hydrogen gas at 0° C. Specific gravity is expressed by numbers which denote how many times as heavy the body is than the standard. The specific gravity (S/G) of mercury is 13.6, which means that it is 13.6 times as heavy as an equal volume of water.

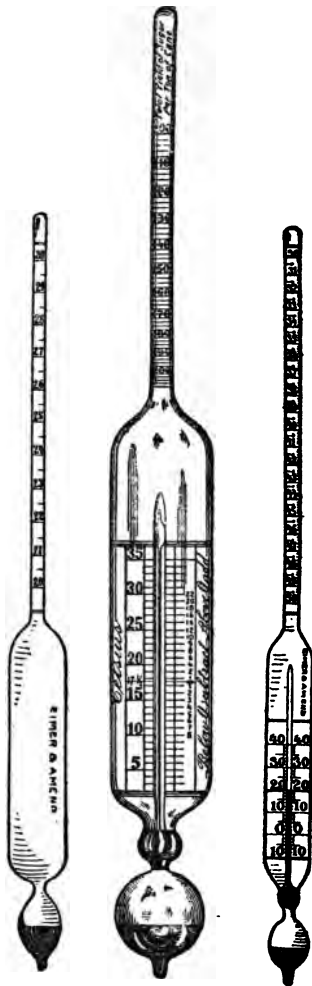


FIG. 1.—Hydrometers.



**Hydrometers** are instruments used for determining the specific gravity of liquids. They are floated in the liquid under examination, and the specific gravity is then read off from the graduated stem, the reading being made at the point to which the hydrometer sinks in the liquid (Fig. 1). When used for some special liquid only, specific names are given the instruments, viz., for milk, "lactometer"; for urine, "urinometer," etc.

### SPECIAL PROPERTIES OF SOLIDS

A solid is distinguished from a liquid or gas in that it possesses definite shape independent of a containing vessel. It therefore follows that solids possess certain distinctive properties, such as **hardness, brittleness, tenacity, malleability** and **ductility**.

**Hardness** is resistance to friction, such as scratching. **Brittleness** is inability to withstand compression. **Tenacity** is resistance to pulling or stretching. **Malleability** is that property of solids whereby they may be hammered or rolled out into thin sheets. **Ductility** is that property by virtue of which solids may be drawn out into wires or threads.

**Crystals** are solid substances bounded by plane faces and definite angles. Substances that have the power of assuming such form are known as **crystalline**, those that have not are known as **amorphous**. The process of assuming crystalline form is known as **crystallization**. According to the relative position, number, and size of the faces, crystals are classified into six systems. In the classification we make use of the term "axes," which designates imaginary lines intersecting at the centre of the crystal. The six systems follow:

**a. The Regular System** (Fig. 2, *a*). All forms have three axes of equal length, intersecting at angles of  $90^\circ$ . In this system we find Sodium Chloride, Potassium Iodide, Potassium Bromide, etc.

**b. The Tetragonal System** (Fig. 2, *b*) has three axes intersecting at angles of  $90^\circ$ , the lateral two being equal in length, and the principal axis either longer or shorter. In this system are found Nickel Sulphate, Potassium Ferrocyanide, Stannic Oxide, etc.

**c. The Rhombic System** (Fig. 2, *c*) has three axes of unequal

length intersecting at angles of  $90^\circ$ . In this are found Citric Acid, Sulphur, Zinc Sulphate, etc.

**d. The Monoclinic System** (Fig. 2, *d*) has three axes, all unequal, two of which intersect at an oblique angle and are perpendicular to the third. In this system are found Tartaric Acid, Ferrous Sulphate, Sodium Sulphate, etc.

**e. The Triclinic System** (Fig. 2, *e*) has three unequal axes, all oblique to one another. In this are found Copper Sulphate, Potassium Dichromate, etc.

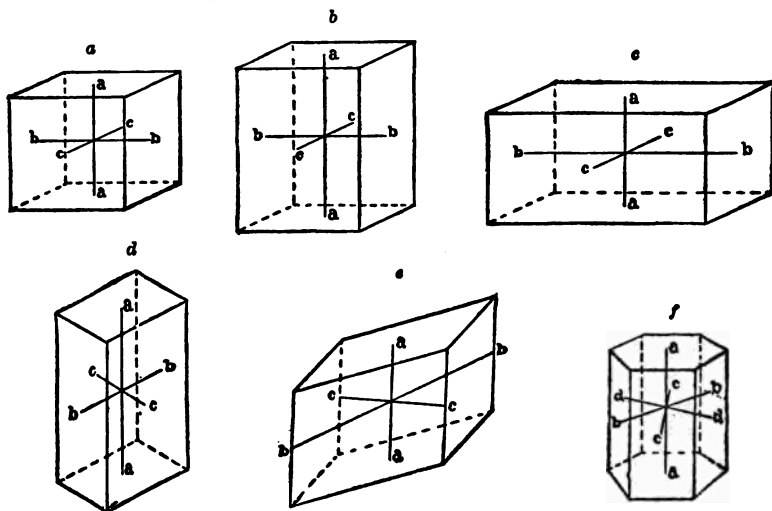


FIG. 2.—The six systems of crystallization.

**f. The Hexagonal System** (Fig. 2, *f*) has four axes; the three lateral axes are of equal length, and intersect each other at angles of  $60^\circ$  and the principal axis at angles of  $90^\circ$ . In this we find Antimony, Bismuth, Thymol, etc.

### SPECIAL PROPERTIES OF LIQUIDS

A remarkable property of liquids is known as the **capillary phenomena**.

**Experiment 1.**—Place a fine glass tube in a vessel containing water, and another in a vessel containing mercury. The water rises in the glass tube and the mercury is depressed (Fig. 3).

An explanation of the above phenomena is dependent upon the properties of matter known as **cohesion** and **adhesion**. **Cohesion** is the attraction existing between like particles, while **adhesion** is that existing between unlike particles. In the case of the water and the glass tube, the *adhesion* between the two is greater than the *cohesion* existing between the particles of water. Therefore the water rises. In the case of the mercury and the glass, the *cohesion* between the particles of the mercury is greater than the *adhesion* of the mercury and the glass. Therefore the mercury is depressed.

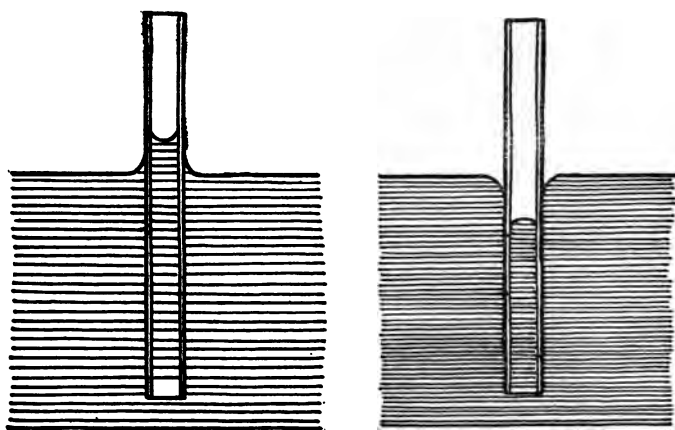


FIG. 3.—Capillary phenomena.  
(water) ← → (mercury)

The property of **diffusion** is closely connected with the capillary phenomena. If two liquids, that are capable of admixture, be placed in the same vessel one above the other so as to form two layers, they will begin to mix or *diffuse* without stirring or shaking, even though the upper liquid be lighter than the lower. This will also take place if the liquids are separated by a porous material, such as a piece of animal membrane. In the latter case the phenomenon is known as **dialysis**. All substances are not diffusible. Those which do not diffuse are called "*colloids*," those which do are termed "*crystalloids*." A piece of apparatus in which dialysis may be carried out is known as a **dialyzer** (Fig. 4).

**Solution.**—When a solid, liquid or gas is brought in contact with a liquid and mixes with it, forming a clear, homogeneous fluid which does not separate upon standing, **solution** is said to be effected. The substance has “*dissolved*” in the liquid. The

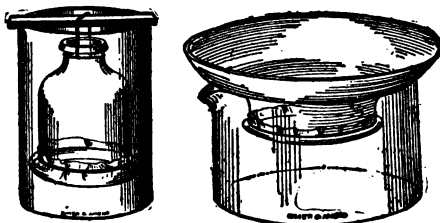


FIG. 4.—Dialyzers.

liquid used to dissolve the substance is called the “*solvent*,” while the homogeneous combination of liquid with solid, liquid or gas is called a “*solution*.” If a substance is not dissolved by



FIG. 5.—Hot-water funnel.



FIG. 6.—Berkefeld house filter. A = un-filtered water. B = filtered water.

a solvent, it is said to be “*insoluble*.” A solution containing as much of a dissolved substance as is possible at that temperature is called a “*saturated solution*.”

**Filtration** is closely related to solution. It may be defined

as a process of separating solid matter from liquids by passing through some porous medium (called a **filter**), which will permit the passage of the liquid *only*. The most common filter is "*filter paper*," although sand, asbestos, glass wool, charcoal, etc., are also employed. **Funnels** made of glass, hard rubber, tinned iron, etc., are used to support filter papers. Special **hot-water funnels** (Fig. 5) are used for filtering fluids that are thick and viscid at ordinary room temperature. An efficient household filter for drinking water is the Berkefeld house filter (Fig. 6).

In pharmacy solvents are used in the "*extractive processes*," i.e., those in which the soluble principles of vegetable drugs are

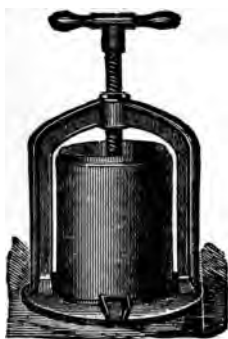


FIG. 7.—Tincture press.

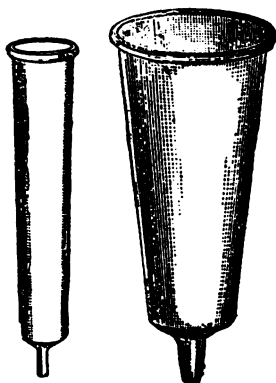


FIG. 8.—Percolators.

dissolved out and separated from the insoluble portions. The solvent in these processes is usually known as the *menstruum*.

**Maceration.**—A process in which a powdered drug is soaked in the proper *menstruum* for a stated length of time, and the mixture of drug and liquid then filtered or **expressed** (**expression** is a process of forcibly separating liquids from solid matter by the use of straining cloths or presses) (see Fig. 7).

**Digestion.**—Maceration at a moderate temperature.

**Infusion.**—A process in which coarsely powdered drugs are treated with cold, hot, or boiling water in a closed vessel, allowed to stand for a time, and finally strained.

**Decoction.**—A process similar to infusion, excepting that the drug and the water are *boiled together*.

**Percolation.**—A process in which a powdered drug is deprived of its soluble constituents by packing it in a suitable vessel, known as a **percolator** (Fig. 8), and allowing the menstruum to gradually descend through it.

## GASES

All gases expand indefinitely. This expansion takes place even in the presence of other gases, and is known as **diffusion**. It is very similar to the diffusion of liquids and will take place through membranes or parchment.

All gases are compressible, the volume varying inversely as the pressure. Thus, if the pressure on a confined gas is doubled, its volume will be reduced one-half. The volume of a gas is also influenced by change in temperature. An increase in temperature causes an increase in volume and a corresponding decrease in the density of the gas. On this fact the principles of **ventilation** are based. Window ventilation for inhabited rooms may be accomplished by leaving a window or windows open, or partly open, at both top and bottom. The warmer, expanded air of the room rises and escapes through the top opening of the windows, and the cooler, more dense air from the outside comes in through the bottom openings. Thus a constant replacement of the air in the room is insured.

The **atmosphere**, the gaseous envelope of the earth, is matter, and therefore has weight, and consequently exerts pressure. The pressure of the atmosphere at sea-level is about fifteen pounds to the square inch, the equivalent of the weight of a column of mercury 760 millimetres or about 30 inches in height. This pressure is known as "*one atmosphere*." As we ascend, atmospheric pressure decreases.

**Experiment 2.**—Completely fill a clean, dry glass tube of ordinary bore, closed at one end and about 80 cm. long, with mercury. Press the forefinger of the right hand firmly over the end of the filled tube and invert in a dish partly filled with mercury, taking care not to remove the finger from the end of the tube until it is well under the surface of the mercury in the dish. After the finger is removed, the mercury in the tube will fall a short distance from the top of the tube. The column of mercury in the tube will remain at a height of approximately 760 mm., and is supported by the atmosphere (Fig. 9).

Atmospheric pressure is measured by an instrument known as a **barometer** (Figs. 10 and 11). The simplest form of barometer is a tube filled with mercury inverted in a vessel containing mercury, suitably mounted in a frame. At sea-level the column

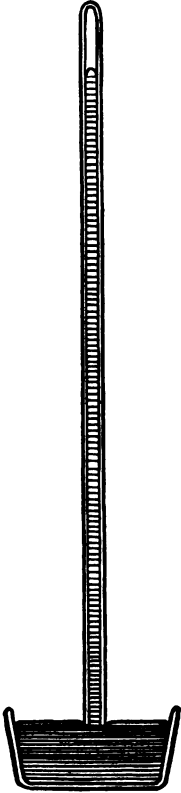


FIG. 9.—A barometer.



FIG. 10.—Siphon barometer.

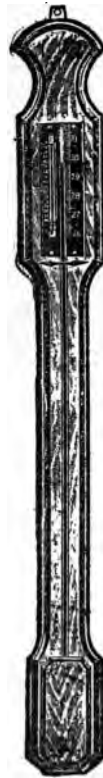


FIG. 11.—U. S. Signal Service barometer.

of mercury in the tube will be about 760 millimetres or 30 inches high. This is due to the fact that the atmosphere exerts pressure upon the surface of the mercury in the vessel and this pressure counterbalances the weight of the column of mercury in the tube. Hence the mercury column falls as atmospheric pressure decreases, and *vice versa*.

The **siphon** is a tube bent at an acute angle, with arms of unequal length and ends open. If the siphon is filled with a liquid, the ends then closed with the thumbs, and the short arm dipped below the surface of a liquid contained in an open vessel, upon removing the thumbs, the liquid will flow through the siphon until the level of liquid in the vessel falls below the short arm. This flow is caused by the difference in pressure at the ends of the siphon. Considering Fig. 12, the pressure at *C* would be equal to the atmospheric pressure minus the weight of the column of liquid, *C-D*; the pressure at *B* is atmospheric pressure minus the weight of the column of liquid *A-B*. This gives pressure at *B* less than the pressure at *C*, therefore the liquid is forced through siphon from *C* to *B*.

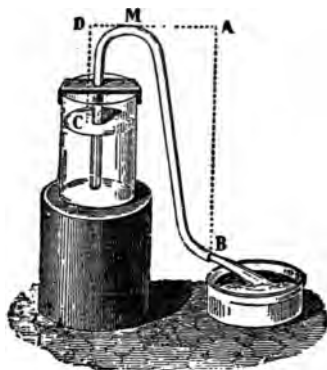


FIG. 12.—Siphon.



## CHAPTER II

### HEAT AND LIGHT

THE molecules of which matter is composed are in a constant state of motion, striking against each other and so producing the forms of molecular energy known as *heat, light, magnetism, and electricity*. We may therefore say that **heat** is a manifestation of molecular motion. The term "cold" is purely relative and indicates a low degree of heat. The sources of heat are the sun, fixed stars, friction, percussion, and chemical changes.

Heat may be transmitted by *radiation, conduction* and *convection*. Heat is transmitted from the sun to the earth by *radiation*; that is, without raising the temperature of the intervening space. If a bar of iron is heated at one end, a rise in temperature is perceptible some distance from the heated point. The heat in this instance is transmitted from particle to particle, and is said to be transmitted by *conduction*. When heat is applied to the bottom of a vessel containing a liquid, the lower layer of liquid becomes heated and moves upward, and a current of cooler liquid moves downward until the liquid is uniformly heated. This is called transmission of heat by *convection*.

Most substances expand upon heating and contract upon cooling. The most important exception to this is water, which contracts to 4° Centigrade and then expands upon further cooling, until at 0° C. it becomes ice. Most liquids, such as mercury, manifest a constant expansion and contraction with change of intensity of heat. This property is made use of in the **thermometer**, an instrument used for measuring the degree of intensity of heat, *i.e.*, the "*temperature*."

The ordinary thermometer consists of a glass tube of small bore with a bulb at one end. The bulb is filled with mercury and is then heated until the mercury rises to the very top of the tube. It is immediately sealed. Two *fixed points* are necessary for the

graduation of the thermometer on any scale. One point is the freezing-point of distilled water, and the other its boiling-point. These are constant points. In this country two scales of graduation are in common use; namely, the **Centigrade** or **Celsius** (C.) and the **Fahrenheit** (F.). On the Centigrade or Celsius scale the freezing-point of water is called "Zero" ( $0^{\circ}$  C.), and the boiling-point 100 degrees ( $100^{\circ}$  C.). On the Fahrenheit scale the freezing-point is labelled 32 degrees ( $32^{\circ}$  F.) and the boiling-point 212 degrees ( $212^{\circ}$  F.).

To convert Centigrade degrees to degrees Fahrenheit: Multiply by 9, divide by 5, and add 32. Thus:  $40^{\circ}$  C.  $\times 9 \div 5 + 32 = 104^{\circ}$  F.

To convert Fahrenheit degrees to degrees Centigrade: Subtract 32, multiply by 5, and divide by 9. Thus:  $104^{\circ}$  F.  $- 32 \times 5 \div 9 = 40^{\circ}$  C.

Another scale, the *Réaumur*, is rarely used. In this scale the freezing-point is  $0^{\circ}$  and the boiling-point is  $80^{\circ}$ .

The clinical thermometer, employed for determining the temperature of the human body, is graduated from  $33.3^{\circ}$  C. ( $92^{\circ}$  F.) to  $43.3^{\circ}$  C. ( $110^{\circ}$  F.), and registers variations of one-fifth of a degree. A small thread of mercury, separated from the main column by a bubble of air, serves to register the maximum temperature, since the thread does not recede with the rest of the column. Before using, the thread of mercury should be shaken down by a sharp jerk of the thermometer.

**Calorimetry.**—Substances are capable of giving off or absorbing heat. An instrument used for determining the amount of heat absorbed or given off by a substance is known as a **calorimeter** (Fig. 15). As a standard for measuring the quantity of heat we use the term **calorie**. This represents the quantity of heat required to raise one gramme of water through one degree Centigrade.

Heat is employed in the following operations:

**Fusion.**—A process of liquefying solids by the application of heat without the aid of a solvent.

**Ignition.**—A process of strongly heating substances whereby

all organic and volatile matter is removed, a solid residue remaining. In chemical analysis this process is usually carried out in cup shaped vessels, made of platinum, porcelain, clay, etc., and known as "**crucibles**" (Fig. 14).

**Calcination.** A process of separating volatile matter, such as water and carbon dioxide, from non-volatile inorganic substances by the application of heat, as in the manufacture of lime (calcium oxide) from limestone or marble (calcium carbonate).

**Deflagration.**—A process in which an inorganic substance capable of giving up oxygen is heated with another inorganic substance; decomposition takes place, usually accompanied by a violent combustion.

**Incineration.**—A process of ap-

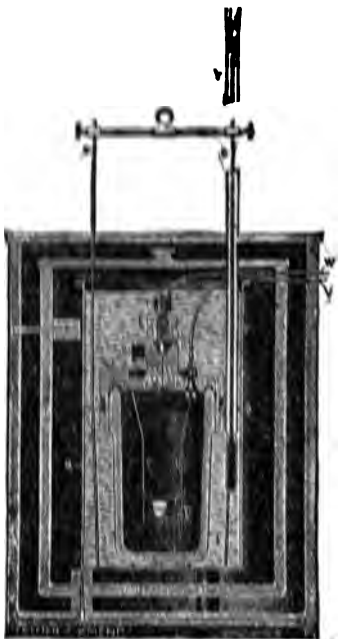


FIG. 13.—Section of Atwater calorimeter.

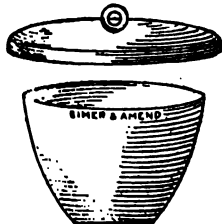


FIG. 14.—Porcelain crucible and cover.

plying strong heat to organic substances *with* free access of air until all carbonaceous matter is consumed and an ash remains.

**Carbonization.**—A process of heating organic substances *without* free access of air until all volatile matter is driven off and a black residue remains, as in the manufacture of wood charcoal.

**Torrefaction or Roasting.**—A process of applying heat to organic substances, alteration in their constituents and properties resulting. A familiar example is the roasting of coffee.

**Vaporization.**—Any process in which volatile substances are separated from non-volatile or less volatile substances by the aid of heat.

**Evaporation.**—Vaporization employed to separate a volatile *liquid* from a less volatile liquid or solid matter in solution.<sup>1</sup> If the object sought is the volatile liquid, the process is known as **distillation**, and the volatile liquid the **distillate**.

**Fractional distillation** is a process of separating a mixture of liquids of different boiling-points by distilling the mixture and collecting the distillates at different temperatures. If a mixture of equal volumes of alcohol and water is distilled, a large portion of the alcohol will distil over at the boiling-point of alcohol (about 78° C.), and, as the percentage of alcohol decreases, the boiling-



FIG. 15.—Copper water-baths.

point of the mixture rises and the distillates are collected at different temperatures. These fractions, in turn, are redistilled as above and all of the alcohol finally separated.

**Destructive distillation** is a process of applying strong heat to organic solids contained in closed iron vessels whereby gases, liquids and thick, tarry products are obtained. A good example of this is the destructive distillation of coal.

Evaporation is carried out in evaporating dishes, beakers, flasks, etc. For controlling the degree of heat, **baths** are used, the most common one being the **water-bath** (Fig. 15).

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<sup>1</sup> The term Evaporation is sometimes confined to those operations in which vaporization takes place from the surface of the liquid *only*. Where evaporation takes place throughout the body of the liquid, the term Ebullition or Boiling is used.

For distillation special apparatus is required, as shown in Fig. 16, the parts being the *retort* (A), condenser (C), receiver (D), and the connecting tubing, the adapters (B). The assembled apparatus is frequently called a **still** (Figs. 17, 18, and 19).

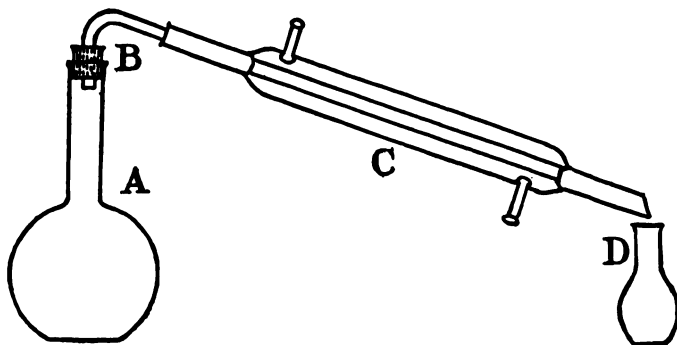


FIG. 16.



FIG. 17.—Stokes automatic water still.



FIG. 18.—Barnstead home still.

**Sublimation.**—Vaporization applied to separate a volatile *solid* from other substances. The product of the process is known as the **sublimate**. The apparatus used is similar to that employed for distillation.

**Desiccation.**—A process of depriving solid substances of moisture at a low temperature. Crude drugs are usually desiccated to aid in their preservation, to reduce their bulk, and to facilitate pulverization. **Ovens** and drying closets are usually employed.



FIG. 19.—Distilling apparatus (still for water, spirits, etc.).

**Exsiccation.**—A process of depriving crystalline substances of their water of crystallization by strongly heating them. The crystals crumble, leaving a powder.

### LIGHT

**Light** is a form of energy which gives rise to the sensation of vision. The principal source of light is the sun. Light travels in waves and is transmitted by some elastic medium. The waves of light are too short to be recognized by human vision, and therefore seem to travel in straight lines or **rays**. A **luminous** body is one which emits light. **Transparent** bodies are those which transmit light rays. **Opaque** bodies do not transmit light rays at all. **Translucent** bodies allow *some* light to pass through them.

Light rays are capable of being reflected. Bodies with polished surfaces employed to show by reflection objects placed before them are known as **mirrors** (Fig. 20). The reflections of such objects are called **images**.

Although a light ray travels in one plane through homogeneous media, it is bent when passing from a denser to a rarer medium, or *vice versa*. This bending of the ray is known as

**refraction** (Fig. 21). It is for this reason that a stick obliquely immersed in water appears broken at the surface.

**Experiment 3.**—Place a coin in a tin basin and assume such a position that the coin is just out of the line of vision. Have some one carefully pour water into the basin in such a way as to avoid moving the coin. The coin will now become visible to the observer, since the rays from the coin are bent *toward* the eye in passing from the denser medium *water* to the rarer medium *air*.

A **prism** is any transparent, refractive body the sides of which form acute angles with each other (Fig. 22).

**Lenses** are prisms whose sides so curve as to cause rays to converge or diverge. According to form, there are six classes

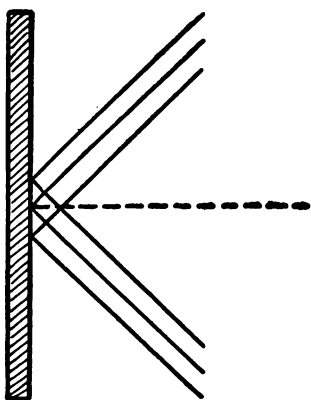


FIG. 20.—Reflection of light rays by a mirror.

(Fig. 23): (A) *Double convex*, (B) *plano-convex*, (C) *concavo-convex*, (D) *double-concave*, (E) *plano-concave*, (F) *convexo-concave*.

Applications of these lenses are made in such instruments as the microscope, polariscope, spectroscope, eye-glasses, etc. (Fig. 25).

**Color.**—White light is composed of rays which have different degrees of refraction. When a ray of white light falls on a prism, it does not come through as white light, but the constituent rays are refracted at different angles which give a band of light containing the colors of the rainbow; *i.e.*, red, orange, yellow, green, blue, indigo, violet. The red rays are refracted least, the violet most. Such a band of colors is called the **prismatic spectrum** (Fig. 26).

The color of an object is determined by the absorption and reflection of the different rays of white light. A body appears red when the red rays are reflected and the others absorbed; a body looks white when all rays are reflected; and so on with the other colors.

**Camera.**—A simple camera consists of a light-proof box, inside of which is fitted a convex lens. The opposite side or back serves

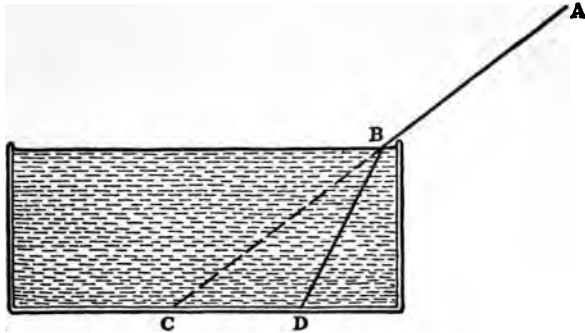


FIG. 21.—Refraction of a light ray by water.

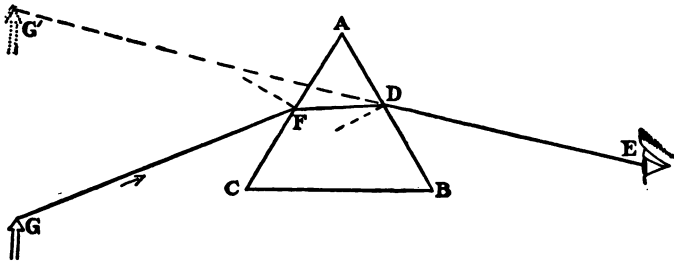


FIG. 22.—Refraction of light ray by a prism.

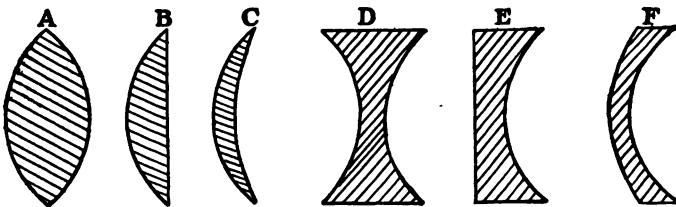


FIG. 23.—Lenses.

as a screen on which images of the objects in front of the camera are formed. The images produced are inverted and are usually smaller than the object. In order to form a sharp image, it is



necessary to move the lens either forward or backward until the image is clearly defined. This is called focussing. When light is shut out by placing a cap over the lens, and a plate-holder containing a sensitized plate is inserted in the back, the slide removed from the plate-holder and the cap removed from the lens, the reflected rays of light from an object in front of the camera rapidly act on the sensitized plate. From the plate, after "developing," which now contains the image, a photograph may be produced.

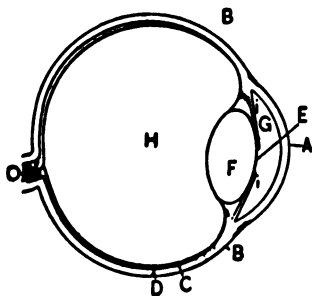


FIG. 24.—Cross-section of the eye.

**The Eye.**—The eye may be com-

pared to a camera, the image produced being communicated by the optic nerve to the brain. Fig. 24 represents a cross-section of the eye. The outer covering of the eyeball, the sclerotic covering *B*, or the white of the eye, constitutes the frame of the camera. The choroid, *C*, is inside of this, and gives the interior of the eye a black lining which is necessary for the absorption of useless rays. In front is the transparent cornea, *A*, set like the crystal of a watch. Directly back of the cornea is the colorless and transparent aqueous humor, *G*, which fills the space between the cornea and the crystalline lens, *F*. Back of this is the jelly-like vitreous humor, *H*, which fills the whole remaining cavity. In front of the crystalline lens is the iris, *i, i*, a diaphragm with a circular opening, which by muscular effort can be contracted or widened at will, and which constitutes the pupil. Spread out over the rear of the cavity is the retina, *D*,



FIG. 25.—A microscope.

which is the sensitized plate of the camera, and, by its connection with the optic nerve, *O*, conveys impressions to the brain.

Like the camera, the eye must be focussed according to the distance to the object. This is accomplished mainly by changing the curvature of the front of the lens by the action of the muscles at either edge of the crystalline lens. For focussing near objects a greater curvature of the lens is required. This is accomplished by exerting strong pressure of the muscles mentioned above. For distant objects less curvature is required and is accomplished by relaxation of the same muscles. When an object is "in focus," a clearly-defined image of it is produced on the retina. When the

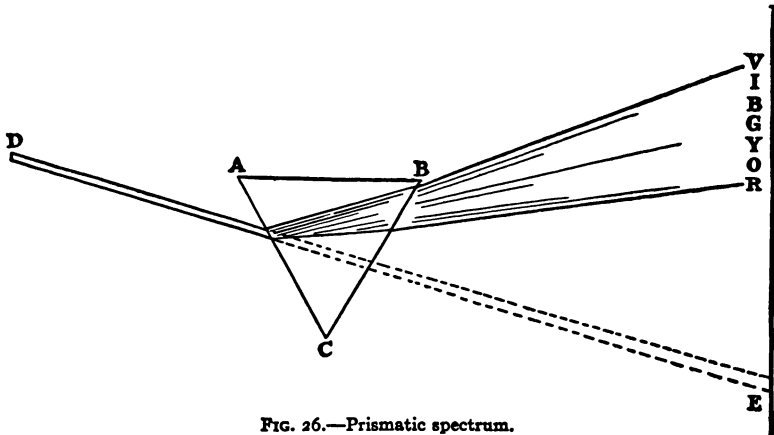


FIG. 26.—Prismatic spectrum.

object is not in focus, the image is thrown either in front or back of the retina, and an indistinct image may be formed. Near-sighted people can see distinctly only at a short distance, and far-sighted people only at a long distance. The usual cause of near-sightedness is too great convexity of the cornea or crystalline lens, causing the image to be formed at a point in front of the retina. This may be overcome by the use of diverging eye-glasses which will throw the image back on the retina. Far-sightedness is caused by an insufficient convergence of the lens of the eye, in consequence of which images are thrown back of the retina. The remedy for this is the use of converging glasses which throw the image *exactly* upon the retina.

## CHAPTER III

### MAGNETISM AND ELECTRICITY

THE native iron ore known as "lodestone" or "magnetite" has the power of attracting bits of steel or iron, and will point North and South when suspended by a thread. All bodies possessing these properties are called **magnets** (Figs. 27 and 28).

Any piece of iron or steel may be magnetized by drawing a magnet over it lengthwise. A magnet has two **poles**,

a *North Pole* and a *South Pole*. The North Pole of a suspended magnet points North; the South Pole, South. If like poles of two magnets are brought in contact they will repel one another; unlike poles will attract.

The **mariner's compass** illustrates the most important application of the magnet. This instrument consists of a small magnetized needle mounted in such a way as to be free to swing under the influence of the earth's magnetic attraction. Calculations may be made from the reading of the compass showing the direction in which the ship is moving.



FIG. 27.—Bar magnet.



FIG. 28.—Horseshoe magnet.

### ELECTRICITY

Like matter and energy, **electricity** can neither be created nor destroyed. It is known to us only by its effects and manifestations. According to the manner of production, electricity is designated as **frictional** ("static"), **inductive**, **chemical** ("galvanic"), and **thermal**.

**Frictional electricity** is of two kinds: positive and negative. That produced on a glass rod by rubbing it with a piece of silk is positive; that produced on hard rubber by rubbing with a piece of flannel is negative. The human body, when rubbed with silk, becomes negatively charged; with wool, positively charged.

**Inductive electricity** is that produced in another body by the mere proximity of an electrified object. Application of this is made in the electrostatic machine and the induction coils (Fig. 29).

**Chemical electricity** is that form produced by chemical reactions. A **galvanic cell** (Figs. 30, 31, and 32) usually consists of a vessel containing an acid mixture in which are placed two plates (ordinarily a zinc and a carbon), one of which is more susceptible to the action of the acid mixture than the other. The one which is acted upon more readily (zinc) is called the positive plate (+); the other (carbon), the negative (-). If these plates are connected

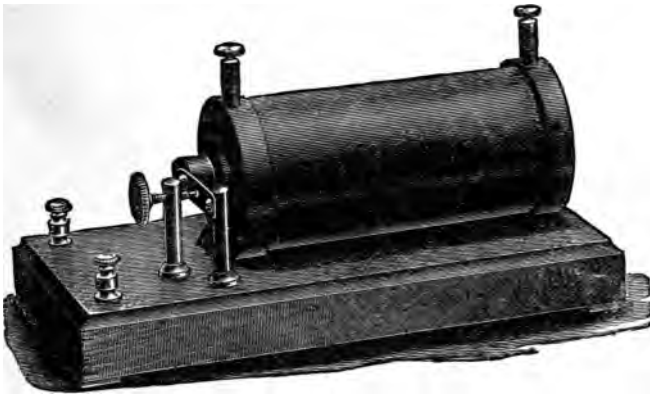


FIG. 29.—An induction coil.

at their terminals by means of copper wires, a passage of what is usually termed an “electric current” takes place through the wires. The copper wires, as well as all other materials which will convey an electric current, are known as **conductors**; those substances which will not are known as **non-conductors**. The ends of the wires leading from the plates are called *poles* or *electrodes*; the one connected with the zinc or positive (+) plate is called the *cathode* or *negative* (-) *pole*, while that connected with the carbon or negative (-) plate is the *anode* or *positive* (+) *pole*. A **battery** is simply a combination of a number of these galvanic cells.

The units of measurement of electricity are named after celebrated workers in this field of science. The **volt** is the unit of

electromotive force ("E.M.F.") of a current, and might be compared to the pressure of water (Fig. 33). The **ampère** is the quantity of electricity that passes through a standard conductor in a second of time. The **ohm** is the unit of resistance, and is equal to the resistance offered by a copper wire, 250 feet long and one-twentieth of an inch in diameter, to a current. The **watt** is the unit of work, and is the power exerted when the current has a strength of one ampère and an electromotive force of one volt.

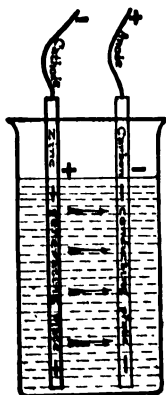


FIG. 30.—A simple galvanic cell.



FIG. 31.—"Bunsen's cell."



FIG. 32.—"Grenet's battery" or bichromate cell.

**Thermal Electricity.**—If two bars of dissimilar metals are soldered together and heated at their junction, electricity is produced. This thermal electric current is usually very feeble, although it is steady and convenient under certain circumstances. The *thermo-electric pile* consists of forty-nine pairs of antimony and bismuth bars arranged in seven rows. Other *piles* are made of pairs of iron and type-metal.

When an electric current from an induction coil is discharged through a gas, the gas is rendered luminous and we have an "electric spark," which, under certain conditions, may exert chemical action. If the discharge of the current takes place in a suitably

constructed glass tube (Crookes tube, Fig. 34) from which almost all the air has been exhausted, a pale purplish beam of light radiates from the negative pole or cathode, and is called the **cathode ray**.



FIG. 33.—Voltmeter for measuring strength of electric currents.

Another kind of rays are also formed in one of these tubes during the generation of the cathode rays. The second kind of rays have

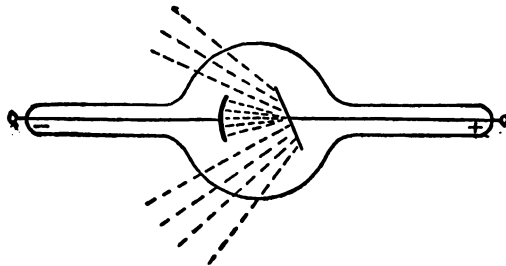


FIG. 34.—A Crookes tube, showing reflected "X-rays."

the peculiar properties of being able to readily pass through objects which are opaque to ordinary light, excite certain fluorescent substances, affect photographic plates, and produce physiological

effects upon the human body. They are called **X-rays** or "**Röntgen rays**" (after their discoverer).

Electric energy is also transformed into heat energy and used for lighting purposes. The **electric arc** light is used for lighting large halls or more commonly for outdoor lighting. If two electrodes of carbon sticks are brought together and a current of proper dimensions is used, a brilliant white light is emitted. The arc light in common use has automatic provisions for keeping the carbon sticks the proper distance apart as they burn away.

The **incandescent light**, the most common form of electric lighting, is made by interposing at some point in the circuit a substance of such high resistance as to change electric energy into heat energy. This heats the conductor to a temperature at which it emits light. The high-resistance conductors or filaments, such as carbon, tungsten, and some of the other rare metals, are usually placed in exhausted glass bulbs with proper metallic connections.

## CHAPTER IV

### ACOUSTICS

ACOUSTICS is that branch of science which treats of the laws of the generation, propagation, and comparison of sound.

All sounding bodies vibrate, and their vibrations set up waves which are communicated to the ear. The **length** of a sound wave is the distance from one wave crest to the next crest (*a* to *b* in Fig. 35). This represents one to-and-fro movement of a vibrating body. The height of a sound wave or its **amplitude** is the distance from the middle point to the limit of vibration; *i.e.*, *a* to *e* and *b* to *f* in figure. For the transmission of sound an elastic medium is necessary, such as air, wood, metals, etc. An appreciable length

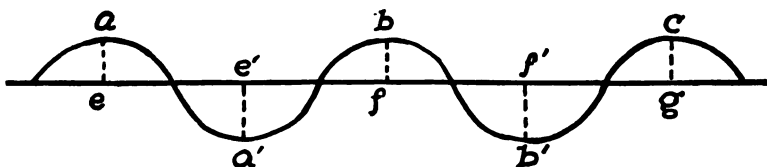


FIG. 35.—Sound wave-motion.

of time is required for the transmission of sound, as may be shown by the discharge of a distant gun, the report being heard after the flash is seen.

**Echo** is reflected sound. If the distance to the reflecting surface is short, the sound is strengthened and gives rise to what is called **resonance**. When a tuning-fork is struck and held on an empty box, or near the open end of an empty box, the sound produced is much louder. The cause of this is that the air within the box vibrates sympathetically with the fork. This principle is employed in the manufacture of violins, pianos, etc.

A **musical sound** is one produced by a succession of vibrations at equal intervals and of sufficient rapidity, as illustrated by the tuning-fork.



The intensity or loudness of sound depends upon the amplitude of the vibrating body. For instance, if the string of a guitar or similar instrument be stretched a short distance and released, then stretched a greater distance and released, the sound in the latter case is much louder than in the former. This is due to the greater amplitude in the latter case.

The ear, the organ of sound, is so constructed as to receive and transmit the sound-wave impressions. The shape of the outward ear, "auricle," is such as to receive sound waves over a comparatively large area, and converge them to the small passage, the "auditory canal," leading to the ear-drum. The impact of the sound-wave particles upon the ear-drum causes it to vibrate. These vibrations reach the auditory nerves and the sensation of sound is produced.

**PART II**  
**INORGANIC CHEMISTRY**



## CHAPTER V

### CHEMICAL PHILOSOPHY

OBSERVATIONS show us that matter is constantly undergoing changes, and these changes may be of two distinctive classes; namely, *physical* and *chemical*.

**Physical Changes.**—Changes of state or condition of matter without alteration of identity are physical; for example, the vaporization of ether, the dissolving of sugar or salt in water, the melting of ice.

**Chemical Changes.**—Changes of composition whereby alterations or destruction of the individual properties and identity of the substances are brought about and some other substance or substances formed in their places are chemical. Examples: the rusting of iron, the burning of wood or coal, the dissolving of a metal in an acid.

**Mechanical Mixtures** are those in which the constituents retain their original properties, no chemical changes having taken place when the substances were brought together. They can be separated into their constituents by mechanical means. If some iron filings and powdered sulphur are thoroughly mixed together, a gray mixture results. This mixture represents a mechanical mixture, since we can remove the iron by passing a magnet through the mixture, or the sulphur may be removed from the iron by dissolving it out with carbon disulphide.

**Chemical Compounds** are substances the constituents of which have lost their characteristic properties, and cannot be separated by mechanical means. If some of the mixture of iron filings and powdered sulphur, mentioned above, is heated in a test-tube, it begins to glow and, when cooled, is found to be a gray-black mass. Upon careful examination, striking changes are noticed. The magnet does not attract the iron, nor does carbon disulphide dissolve the sulphur. A new substance must have been formed, which is the **chemical compound** called iron sulphide.

**Experiment 4.**—(a) In a small mortar mix some iron filings and powdered sulphur until a uniform mixture is obtained. Examine some of the mixture with a magnifying glass or microscope. What can you distinguish?

(b) Pass a small magnet through some of the mixture. What adheres to the magnet?

(c) Treat some of the mixture with some carbon disulphide in a test-tube. Shake well and filter into a small evaporating dish. Allow the contents of the dish to stand until all the liquid has evaporated. What remains in the dish? What remains on the filter paper?

(d) Heat some of the mixture of iron and sulphur in a dry test-tube over the open flame until the entire mass glows. When cool, remove the mass and examine closely. Are particles of iron and sulphur distinguishable? Treat some of the mass with carbon disulphide and filter as above. Allow the filtered liquid to evaporate. Is sulphur found in the dish? Are iron filings left on the filter paper?

Why is the mixture of iron filings and sulphur, *before heating*, a mechanical mixture? What is formed when the mixture is heated?

The chemical changes that we have referred to are known as **reactions**. They may be divided into two classes; namely, **synthetic** and **analytic**.

**Synthetic changes or reactions** are those in which substances unite, producing new compounds with new properties, as sulphur and iron in the foregoing experiment.

**Analytic changes or reactions** are those in which chemical compounds are resolved into their constituents.

**Experiment 5.**—Heat a small quantity of "Red precipitate" (a compound of mercury and oxygen known also as red mercuric oxide) in a test-tube over the open flame. After heating for some minutes, insert a splint, with a spark on the end of it, into the tube. What takes place? Allow the tube to cool, and examine the inside surface of the tube near the mouth. What is found? The explosion that took place when the spark was inserted was due to the union of a gas (oxygen), that was liberated from the "Red precipitate" through the agency of the heat, with the carbon of the splint; while the silvery-white globules on the inside of the tube are globules of metallic mercury, the other constituent of "Red precipitate." What kind of chemical change would you call this?

In all of the reactions or changes that we have referred to, it must be seen that there is some agency which causes the union of substances when new compounds result, and that this agency must be overcome in order to resolve a chemical compound into its constituents. This agency or force is known as **chemical affinity** and may be defined as that force which causes substances to combine and which holds them together when combined. All substances possess this chemical affinity in a greater or less degree,

and manifest it differently under varying conditions. Some substances combine with comparative ease, while others require the agency of some other force to bring about chemical combination.

**Chemistry** is that science which treats of the composition of matter and the changes in composition.

**Elements** are substances which cannot be separated into simpler substances by any known means, as iron, sulphur, gold, mercury, oxygen. Chemical compounds are made up of elements, and in expressing the composition of such compounds it is necessary, for the sake of simplicity, to use abbreviations for the elements that compose it. Such abbreviations are known as **chemical symbols**, and are usually made up of the initial letter of the name of the element, or, in cases where the names of two or more elements begin with the same letter, the initial letter and one other letter of the name are used. Thus, the symbol for Sulphur is "S"; for Oxygen, "O"; for Carbon, "C"; for Calcium, "Ca"; for Fluorine, "F"; for Iron, "Fe" (*the Latin title for iron is "Ferrum"*), etc.

TABLE OF THE ELEMENTS

Name.	Symbol.	Atomic weight, H=1.	Valence.
Aluminium.....	Al	26.9	III
Antimony ( <i>see Stibium</i> )			
Argentum ( <i>Silver</i> ).....	Ag	107.89	I
Argon.....	A	39.6	
Arsenic.....	As	74.45	III, V
Aurum ( <i>Gold</i> ).....	Au	196.7	I, III
Barium.....	Ba	136.4	II
Beryllium.....	Be	9.03	II
Bismuth.....	Bi	206.5	III
Boron.....	B	10.9	III
Bromine.....	Br	79.34	I, III, V, VII
Cadmium.....	Cd	111.5	II
Calcium.....	Ca	39.8	II
Carbon.....	C	11.9	IV
Cerium.....	Ce	138.0	III, IV
Cesium.....	Cs	132.7	I
Chlorine.....	Cl	35.18	I, III, V, VII
Chromium.....	Cr	51.7	II, III, VI
Cobalt.....	Co	58.6	II, III
Columbium.....	Cb	93.7	V
Copper ( <i>see Cuprum</i> )			

TABLE OF THE ELEMENTS—*Continued*

Name.	Symbol.	Atomic weight, H=1.	Valence.
Coronium.....	Cm		
Cuprum ( <i>Copper</i> ).....	Cu	63.18	I, II
Erbium.....	Er	166.0	III
Ferrum ( <i>Iron</i> ).....	Fe	55.88	II, III
Fluorine.....	F	19.0	I
Gadolinium.....	Gd	156.1	III
Gallium.....	Ga	69.9	III
Germanium.....	Ge	72.3	II, IV
Glucinum ( <i>see Beryllium</i> )			
Gold ( <i>see Aurum</i> )			
Helium.....	He	4.0	
Hydrargyrum ( <i>Mercury</i> ).....	Hg	189.5	I, II
Hydrogen.....	H	1.0	I
Indium.....	In	113.6	II
Iodine.....	I	125.89	I, III, V, VII
Iridium.....	Ir	192.5	II, IV, VI
Iron ( <i>see Ferrum</i> )			
Kalium ( <i>Potassium</i> ).....	K	38.82	I
Krypton.....	Kr	81.2	
Lanthanum.....	La	138.2	III
Lead ( <i>see Plumbum</i> )			
Lithium.....	Li	6.97	I
Magnesium.....	Mg	24.1	II
Manganese.....	Mn	54.6	II, III, IV
Masrium.....	Ms	228.0	
Mercury ( <i>see Hydrargyrum</i> )			
Metargon.....	.....	40.0	
Molybdenum.....	Mo	95.9	II, IV, VI
Natrium ( <i>Sodium</i> ).....	Na	22.88	I
Neodymium.....	Nd	140.5	III, IV
Neon.....	Ne	20.0	.
Nickel.....	Ni	58.6	II, III
Niobium ( <i>see Columbium</i> )			
Nitrogen.....	N	13.93	III, V
Osmium.....	Os	190.3	II, IV, VI, VIII
Oxygen.....	O	15.88	II
Palladium.....	Pd	106.35	III, IV
Phosphorus.....	P	30.75	III, V
Platinum.....	Pt	194.3	II, IV
Plumbum ( <i>Lead</i> ).....	Pb	205.36	II, IV
Potassium ( <i>see Kalium</i> )			
Praseodymium.....	Pr	143.5	II
Radium.....	Ra	223.0	II
Rhodium.....	Rh	102.9	III
Rubidium.....	Rb	85.2	I
Ruthenium.....	Ru	101.4	II, IV, VI, VIII
Samarium.....	Sm	149.6	III, V

TABLE OF THE ELEMENTS—*Continued*

Name.	Symbol.	Atomic weight, H=1.	Valence
Scandium.....	Sc	43.9	III
Selenium.....	Se	78.9	II, IV, VI
Silicon.....	Si	28.2	IV
Silver ( <i>see Argentum</i> )			
Sodium ( <i>see Natrium</i> )			
Stannum ( <i>Tin</i> ).....	Sn	118.1	II, IV
Stibium ( <i>Antimony</i> ).....	Sb	119.6	III, V
Strontium.....	Sr	86.95	II, IV
Sulphur.....	S	31.83	II, IV, VI
Tantalum.....	Ta	182.0	III, V
Tellurium.....	Te	125.0	II, IV, VI
Terbium.....	Tb	159.1	III
Thallium.....	Tl	203.7	I, III
Thorium.....	Th	230.8	IV
Thulium.....	Tu	170.7	III
Tin ( <i>see Stannum</i> )			
Titanium.....	Ti	48.0	II, IV
Tungsten ( <i>see Wolfram</i> )			
Uranium.....	U	239.5	II, IV, VIII
Vanadium.....	V	51.1	III, V
Wolfram ( <i>Tungsten</i> ).....	W	183.6	II, IV, VI
Xenon.....	Xe	128.0	
Ytterbium.....	Yb	172.6	III
Yttrium.....	Yt	88.9	III
Zinc.....	Zn	64.9	II
Zirconium.....	Zr	90.4	II, IV

When the symbols for elements are assembled to show the composition of a chemical compound, the arrangement of symbols is called a **chemical formula**. For example:  $\text{H}_2\text{O}$  represents a compound whose molecule is made up of two atoms of hydrogen and one of oxygen. From this we see that the symbols have a quantitative significance. Each symbol represents an *atom* of the element. Thus, "O" does not represent an indefinite quantity of oxygen, nor "H" an indefinite quantity of hydrogen; but, instead, they represent *one atom* of the elements in question; and, since atoms are matter, these atoms possess definite weight. Therefore a symbol represents a definite weight of an element, and this weight is known as the **atomic weight**. However, since an atom cannot be weighed directly, **atomic weights** are relative quantities. They are estimated by comparison with a standard



element. The oldest standard is hydrogen, which was chosen because it is the lightest of the known elements, and is assigned an atomic weight of unity, or 1.00. If we weigh equal volumes of hydrogen and oxygen gases under the same pressure and temperature, we will find that the volume of oxygen is 15.88 times as heavy as the hydrogen; therefore it follows that an atom of oxygen is 15.88 times as heavy as an atom of hydrogen, since equal volumes of gases contain the same number of molecules, and each molecule of oxygen and hydrogen consists of two atoms of these elements (Avogadro's law). We may say then that the **atomic weight** of an element is the relative weight of its atoms as compared to those of the standard. A later system of atomic weights has oxygen ( $O = 16$ ) as the standard. The **molecular weight** of an element or a compound is the sum of the atomic weights of the atoms forming the molecule. Thus:  $H_2$ , a molecule of hydrogen, consisting of two atoms of the element, has a molecular weight of 2;  $H_2O$ , a molecule of water, consisting of two atoms of hydrogen and one of oxygen, has a molecular weight of 17.88 ( $H = 1$ ;  $O = 15.88$ ).

A study of the formulæ of various compounds shows that the elements differ among themselves in the number of atoms of other elements which they are able to hold in combination. This is illustrated in the formulæ:



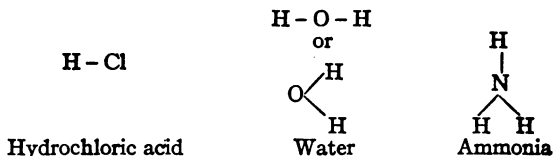
We notice that one atom of chlorine (Cl) combines with one atom of hydrogen, one atom of oxygen combines with two atoms of hydrogen, and that one atom of nitrogen (N) combines with three atoms of hydrogen. The number which expresses this combining ratio between atoms is a definite property of an element, and is called **valence**. **Valence**, then, is that property of an element which determines the number of atoms of another element which its atom can hold in combination. Valence is merely a numerical relation and is measured by comparison to a standard. It has been found that an atom of hydrogen is never able to hold in combination more than one atom of any other element, and for this reason has been chosen as the standard.

Elements which unite with one atom of hydrogen are called **univalent** or **monads**; those which combine with two of hydrogen, **divalent** or **diads**; with three, **trivalent** or **triads**, etc.

Many elements do not readily form compounds with hydrogen, and their valence is therefore not easily determined by comparing directly to the standard. These elements, however, combine with other univalent elements, such as chlorine, and their valence may be indirectly determined from the compound thus formed. For example: Sodium does not directly combine with hydrogen, but does combine with chlorine to form sodium chloride, NaCl. Since chlorine unites directly with hydrogen to form hydrochloric acid, HCl, it is univalent; therefore sodium is also univalent.

The same element may possess a different valence in different compounds. In the compound hydrogen sulphide, H<sub>2</sub>S, sulphur is divalent, while in sulphur dioxide, SO<sub>2</sub>, it is tetravalent. The valence of the various elements will become familiar as the elements and their compounds are studied in detail.

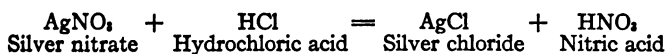
If it is desired to indicate the valence of an element, a Roman numeral or strokes may be placed to the right above the symbol. For example: O<sup>II</sup>, N<sup>III</sup>, S<sup>II</sup>, Ca<sup>II</sup>, Cl<sup>I</sup>, or O'', N''', S'', Ca'', Cl'. In some instances it is desirable to indicate the valence by small lines, called "**bonds**," placed to the sides of the symbols, so as to show the linking of atoms to one another. Examples:



#### VALENCE TABLE

Usual valence	More common elements (symbols)
I. ....	H, Cl, Br, I, F, Agg( <i>ous</i> ), H, Cu( <i>ous</i> ), Na, K, Li
II. ....	O, S, Hg( <i>ic</i> ), Pb, Cu( <i>ic</i> ), Cd, Co, Ni, Fe( <i>ous</i> ), Cr( <i>ous</i> ), Mn( <i>ous</i> ), Sn( <i>ous</i> ), Zn, Ca, Ba, Sr, Mg
III. ....	N, P, Cl, B, Bi, Co, Fe( <i>ic</i> ), Al, Cr, As, Sb, Au
IV. ....	C, S, Si, Sn( <i>ic</i> ), Pt
V. ....	N, P, Cl, As, Br, I
VI. ....	S, Cr, Mn
VII. ....	N, Cl, Br, I
VIII. ....	Os, Ru, U

**Chemical Equations.**—We have seen that the composition of substances can be expressed by symbols and formulæ which show the kind of elements and their proportions present in them. A concise method of representing what takes place in a chemical change or reaction has been devised for simplicity. This is accomplished by the use of “**chemical equations.**” Such an equation is formed by writing the formulæ of the substances that take part in the reaction on the left of the sign of equality (=), and connecting them by the plus sign (+); and the formulæ of the products of the reaction on the right of the sign of equality, also connected by the plus sign. For example:



The plus sign should be read “*and*,” and the equality sign should be read “*give*.”

This, like all equations, conforms to the rule that when two or more reacting substances are brought together under proper conditions an interchange of elements takes place and new combinations are made. In the above, an atom of chlorine of the hydrochloric acid, owing to its greater affinity, attaches itself to an atom of silver, displacing the group of atoms  $\text{NO}_3$  (called a “**radical**”), and forming silver chloride. The radical  $\text{NO}_3$  immediately attaches itself to an atom of hydrogen, forming nitric acid. The sum of the molecular weights of the products on the right of the equality sign must equal the sum of the molecular weights of substances on the left, according to the law of the indestructibility of matter. All elements which enter into the reaction as factors on the left of the equation must be accounted for on the right.

In using numerals for symbols, formulæ, and equations the usual laws of arithmetic are followed. A small numeral placed to the lower right side of a symbol or group of symbols in parentheses multiplies that symbol or group within the parentheses *only*. Examples:  $\text{K}_2$  means 2 atoms (*one molecule*) of potassium;  $(\text{NO}_2)_2$  = 2 atoms of nitrogen (N) and 6 ( $2 \times 3$ ) of oxygen. A large

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<sup>1</sup> A *radical* is a theoretical group of atoms which departs itself in chemical reactions like a single atom. Examples:  $\text{NO}_3^1$ ,  $\text{SO}_4^{11}$ ,  $\text{PO}_4^{111}$ .

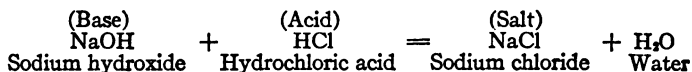
numeral placed to the left of a symbol or formula multiplies what follows. Examples:  $2K = 2$  atoms of potassium;  $2HNO_3$  (nitric acid) = two molecules of nitric acid, consisting of 2 atoms of hydrogen, 2 of nitrogen, and 6 of oxygen.

**Acids.**—An acid is a substance consisting of hydrogen and a non-metallic element or radical, which usually has a sour taste, turns litmus red, and is capable of reacting with a base to form a salt and water. The hydrogen of acids is replaceable by metals. Where an acid has only one hydrogen atom that is replaceable by a metallic atom, it is known as a **monobasic** acid; where it has two replaceable hydrogen atoms, a **dibasic** acid; three, **tribasic**, etc. Examples:  $HCl$ , hydrochloric acid;  $H_2SO_4$ , sulphuric acid;  $H_3PO_4$ , phosphoric acid.

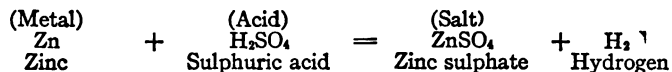
**Bases.**—A base is a compound in which a metallic element is linked to hydrogen by means of oxygen, turns litmus blue, and is capable of reacting with an acid, forming a salt and water. Bases are commonly known as “hydroxides,” all of them having the common group of atoms  $OH$  (called “*hydroxyl*”). Where a base has but one  $OH$  group it is called **mono-acid**; two, **di-acid**; three, **tri-acid**. Examples:  $NaOH$ , sodium hydroxide;  $Ca(OH)_2$ , calcium hydroxide;  $Bi(OH)_3$ , bismuth hydroxide.

**Neutralization** is a term used to express interaction between acids and bases, with the result that both acid and basic properties disappear; *i.e.*, the base and the acid are “neutralized.” One of the products of such a reaction is a **salt**.

**Salts.**—Salts are products of the interaction between acids and bases. Example:



Salts may also be formed by the action of an acid on a metal. Example:



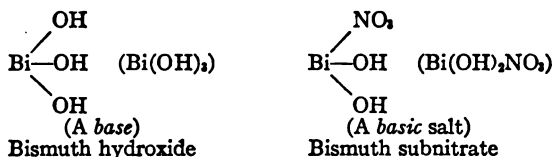
We may divide salts into four classes: (1) *Normal or neutral*, (2) *acid*, (3) *double*, (4) *basic*.

**Normal or Neutral Salts.**—These are formed by the replacement of *all* of the replaceable hydrogen of an acid by a metal. In the above equation zinc sulphate,  $\text{ZnSO}_4$ , is a *normal salt*, since all of the hydrogen of the sulphuric acid,  $\text{H}_2\text{SO}_4$ , has been replaced by the metal zinc.

**Acid Salts.**—These are formed by the partial replacement of the replaceable hydrogen of acids by a metal. They are called "*acid*," "*bi-*" or "*hydrogen*" salts. Examples:  $\text{NaHSO}_4$ , sodium acid (bi- or hydrogen) sulphate;  $\text{NaHCO}_3$ , sodium acid (bi- or hydrogen) carbonate.

**Double salts** are formed by the replacement of the hydrogen of an acid by more than one metal. Example:  $\text{KNaSO}_4$ , potassium sodium sulphate.

**Basic salts** are formed by the replacement of part of the hydroxyl groups (OH) of a base by acid radicals. They are commonly called "*oxy-*" or "*sub-*" salts. Example:



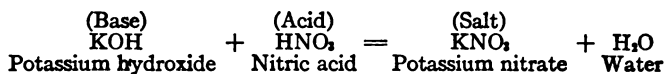
**Experiment 6.**—(a) Dilute some hydrochloric acid with five or six times as much water. Moisten a strip of blue and a strip of red litmus paper<sup>2</sup> with some of the diluted solution. Which color is affected? This turning of blue litmus paper to a red color is known as "*an acid reaction to litmus*."

(b) Repeat the same with some diluted solution of sodium hydroxide. Which color is affected? This color reaction—i.e., red to blue—is referred to as "*an alkaline reaction to litmus*."

(c) Now add to the acid solution the solution of sodium hydroxide in very small quantities, stirring after each addition and testing with litmus paper, until a point is reached where the mixture produces no effect upon either the red or blue papers. The mixture is now said to be "*neutral in reaction to litmus*." Taste the solution. The reaction that has taken place is represented by the first equation under "*Salts*" above.

<sup>2</sup> Blue and red litmus paper is made by impregnating strips of unsized white paper with the blue solution that is obtained by properly extracting litmus, a lichen, with boiling alcohol, cold and finally with boiling water; or with this solution after just enough hydrochloric acid has been added to impart a distinct red tint. Substances, like litmus, which indicate by some striking phenomenon (such as a change in color, formation or cessation of a precipitate, etc.) the completion of a chemical reaction, are called "*Indicators*."

**Experiment 7.**—Repeat the above experiment, using diluted solutions of potassium hydroxide (KOH) and nitric acid (HNO<sub>3</sub>). The reaction that takes place is represented by the following equation:



**Radicals** (also called “Residues” or “Compound radicals”) have already been referred to as theoretical groups of atoms which deport themselves in chemical reactions like single atoms. These groups have no separate existence, but are “unsaturated”; *i.e.*, they are capable of combining with more atoms, since their affinities are not satisfied. For example: In the compound water, H<sub>2</sub>O, the divalent oxygen combines with two atoms of the univalent hydrogen, forming a “saturated” compound, all affinities being satisfied.  $\begin{array}{c} \text{H} \\ \text{H} \end{array} \text{O}$  Now if we take from the molecule H<sub>2</sub>O one atom of hydrogen, the group of atoms  $\begin{array}{c} \text{H} \\ \text{O} \end{array}$ , with one point of affinity “unsaturated,” is left. This group, OH, enters into many compounds; it is, for example, a constituent of all the hydroxides, such as sodium hydroxide, NaOH; potassium hydroxide, KOH; calcium hydroxide, Ca(OH)<sub>2</sub>, etc. According to the number of *unsaturated* points of affinity in a radical, we have univalent, divalent, trivalent, and tetravalent radicals. Examples: OH', NO<sub>2</sub>', SO<sub>4</sub>'', PO<sub>4</sub>''', SO<sub>3</sub>'', CO<sub>3</sub>'', ClO<sub>3</sub>', P<sub>2</sub>O<sub>7</sub>'''', etc.

**Ionization or Electrolytic Dissociation.**—There are strong grounds for believing that when many compounds enter into solution they undergo a peculiar form of disintegration, called “*Ionization*” or “*Electrolytic dissociation*.” This is especially true in the cases of acids, bases, and salts. Using common salt (sodium chloride, NaCl) as an example: When we dissolve sodium chloride in water some of the molecules of the compound disintegrate into two parts or particles, which are chemically sodium and chlorine, but which differ from ordinary elemental sodium and chlorine in that they possess electrical charges. These particles are called “*ions*.”

If the poles or electrodes of a battery are placed in such a solution, it will be found that one kind of ions are attracted by the

anode or positive pole, while the other kind are attracted by the cathode or negative pole. In the case of the sodium chloride solution, the sodium ions are attracted by the cathode, and are called "*cations*"; while the chlorine ions are attracted by the anode, and are called "*anions*." Such a process is known as **electrolysis**; and a solution or substance in the liquid condition, which will conduct an electric current while undergoing decomposition, is called an **electrolyte**.

Whenever a molecule of a substance undergoes electrolytic disintegration or dissociation, one part is charged positively, or is a *cation*; while the other is always charged negatively, or is an *anion*. It has been observed that liquids which contain no dissociated molecules (*ions*) do not conduct the electric current; while those which do are relatively ready conductors. It has been further noticed that many compounds are inactive chemically and physiologically unless they are in the dissociated or ionized condition. Thus, mercuric chloride ( $\text{HgCl}_2$ ) when in the dry condition is inactive chemically and as a disinfectant; while in aqueous solution it is active both chemically and as a disinfectant. Some compounds which ionize in water will not do so when dissolved in other liquids. Thus, phenol ("*Carbolic acid*"), an active disinfectant when in aqueous solution, has no disinfecting powers when dissolved in alcohol or oils. It therefore appears that with such compounds chemical reactions take place between their ions rather than the molecules.

**Chemical Nomenclature** should systematically indicate the chemical composition of compounds. In writing the formulæ for binary compounds,—*i.e.*, those composed of two elements,—the electropositive element or cation is placed first, and is followed by the electronegative element or anion. Thus, the formula of potassium chloride is written  $\overset{+}{\text{K}}\bar{\text{Cl}}$ , and not  $\bar{\text{Cl}}\overset{+}{\text{K}}$ . In naming such compounds the same order is followed, the last syllable being *ide*; as potassium chloride,  $\text{KCl}$ ; calcium sulphide,  $\text{CaS}$ ; zinc oxide,  $\text{ZnO}$ . Thus in all binary compounds the ending is *ide*, added to the stem of the electronegative element.

Where two elements form two different compounds, the products may be distinguished by terminating the name of the

electropositive element or cation in *ous* or *ic*. The suffix *ous* indicates a lower percentage of the electronegative, and *ic* a higher percentage; as  $\text{Hg}_2\text{O}$ , mercurous oxide, and  $\text{HgO}$ , mercuric oxide.

Where several compounds are formed by the two uniting elements the products may be distinguished by prefixing Greek numerals to the electronegative element. Thus,  $\text{N}_2\text{O}$ , nitrogen monoxide;  $\text{N}_2\text{O}_2$ , nitrogen dioxide;  $\text{N}_2\text{O}_3$ , nitrogen trioxide;  $\text{N}_2\text{O}_4$ , nitrogen tetroxide;  $\text{N}_2\text{O}_5$ , nitrogen, pentoxide.

In the case of binary acids it has been the custom to employ the term "acid," and to precede the name of the electronegative element ending in *ic* with the prefix "hydro"; as,  $\text{HCl}$ , hydrochloric acid instead of hydrogen chloride. The salts of these acids end in *ide*; as,  $\text{KCl}$ , potassium chloride.

Where acids are composed of three elements they are called *ternary* or *oxy-acids* (since the third element is oxygen). Some elements form several oxy-acids which differ in the percentage of oxygen present. If there are only two, they are distinguished by the suffixes *ous* and *ic*; as,  $\text{HNO}_2$ , nitrous acid;  $\text{HNO}_3$ , nitric acid;  $\text{H}_2\text{SO}_3$ , sulphurous acid;  $\text{H}_2\text{SO}_4$ , sulphuric acid. Where there are more than two acids formed, the one containing the least percentage of oxygen is designated by the prefix *hypo* and the suffix *ous*; the one containing the next higher percentage of oxygen, by the suffix *ous*; the next by the suffix *ic*; and the one containing the highest percentage of oxygen by the prefix *per* and the suffix *ic*. Thus:  $\text{HClO}$ , hypochlorous acid;  $\text{HClO}_2$ , chlorous acid;  $\text{HClO}_3$ , chloric acid;  $\text{HClO}_4$ , perchloric acid.

Salts of the *ous* oxy-acids end in the suffix *ite*. Thus:  $\text{NaNO}_2$ , sodium nitrite, a salt of nitrous acid;  $\text{K}_2\text{SO}_3$ , potassium sulphite, a salt of sulphurous acid. Salts of the *ic* oxy-acids end in the suffix *ate*. Thus:  $\text{NaNO}_3$ , sodium nitrate, a salt of nitric acid;  $\text{K}_2\text{SO}_4$ , potassium sulphate, a salt of sulphuric acid.

The following antiquated prefixes are used at times: *proto*, meaning the first of a series of compounds, as  $\text{HgCl}$ , protochloride of mercury; *bi*, *bin*, *di*, or *deuto*, referring to the num-



ber of atoms of the electronegative element in the molecule, as  $\text{HgCl}_2$ ,—*bichloride* of mercury; *sub*, meaning “below” or “under,” referring to a lower percentage of the electronegative element, as  $\text{Hg}_2\text{O}$ , *suboxide* of mercury; *per*, indicating that the compound has the highest possible percentage of the electronegative element, as  $\text{FeCl}_3$ , *perchloride* of iron; and *sesqui*, referring to a ratio of 2 atoms of the electropositive element to 3 atoms of the electronegative, as  $\text{Fe}_2\text{O}_3$ , *sesquioxide* of iron.

**Oxidation and Reduction.**—Chemical reactions which result in an increase in the proportionate amount of the non-metallic ion are processes of *oxidation*. Thus: Ferrous chloride,  $\text{FeCl}_2$ , may be *oxidized* to ferric chloride,  $\text{FeCl}_3$  ( $\text{FeCl}_2 + \text{Cl} = \text{FeCl}_3$ ).

Chemical reactions in which the reverse of the foregoing takes place,—that is, decrease in the proportionate amount of the non-metallic ion,—are called *reduction* processes. Thus: Ferric chloride,  $\text{FeCl}_3$ , may be *reduced* to ferrous chloride,  $\text{FeCl}_2$  ( $\text{FeCl}_3 + \text{H} = \text{FeCl}_2 + \text{HCl}$ ).

## CHAPTER VI

### THE METALS

**Metals** are *solid*, elemental substances (except mercury), good conductors of heat and electricity, whose hydroxides are bases.

Gold, silver, mercury, tin, copper, zinc, lead, and iron were known to the ancients. The symbols for all of these were derived from their Latin titles. The symbol for **gold** is *Au*, from *Aurum*; for **silver**, *Ag*, from *Argentum*; for **mercury**, *Hg*, from *Hydrargyrum*; for **tin**, *Sn*, from *Stannum*; for **copper**, *Cu*, from *Cuprum*; for **zinc**, *Zn*, from *Zincum*; for **lead**, *Pb*, from *Plumbum*; for **iron**, *Fe*, from *Ferrum*. The remaining metals are of more recent discovery, and their names were derived from the name of the discoverer, the name of the native land of the discoverer, or from some peculiar or characteristic property of the element.

**Sources.**—Some of the metals occur in the free condition, such as gold, platinum, silver, and mercury. Most of the others occur in chemical combination as sulphides, oxides, carbonates, and silicates.

**Extraction.**—Nearly all of the metals can be extracted from their ores by heating processes in special furnaces. The details of such methods are too complicated for a text-book of this kind. The student is referred to advanced texts on chemistry and metallurgy for additional information.

**Physical Properties.**—At ordinary temperatures all metals are solid *except* mercury. Mercury is a solid at about  $-40^{\circ}\text{C.}$ , a liquid at temperatures up to about  $360^{\circ}\text{C.}$ , at which point it is converted into a vapor. Metals are opaque, excepting when hammered out into very thin sheets. Those that occur in the free state are usually crystalline in structure. They all possess a metallic lustre, and are capable of taking on a high polish. Most of them are more or less white in color, with a blue or gray tinge. Gold is *yellow*, iron is *white*, bismuth (Bi) and cobalt (Co) have a *pink* tinge, copper is *red*, silver is *white*, lead, zinc, and tin are *gray-white*,

mercury is a *silvery-white liquid*, sodium (Na) and potassium (K) are *silver-white* and of *waxy* consistence.

The specific gravity of metals varies greatly. All the metals composing what is known as the **alkali group** (K, Na, and Li) are lighter than water; the others are heavier. Malleability, ductility, and hardness also vary greatly.

**Chemical Properties.**—The heavier metals are generally less active than the lighter ones. **Solubility:** Nitric acid ( $\text{HNO}_3$ ) is the best general solvent for the metals. It dissolves all except gold, platinum, aluminium (Al), tin, and antimony (Sb). Hydrochloric acid ( $\text{HCl}$ ) dissolves all metals except mercury, bismuth, antimony, silver, gold, lead, platinum. Strong sulphuric acid ( $\text{H}_2\text{SO}_4$ ) has very little effect upon the metals, but, *if diluted*, dissolves all except aluminium, antimony, lead, gold, platinum, copper, and mercury. The mixture of hydrochloric and nitric acids (82 Cc. to 18 Cc.), known as "**Aqua regia**," dissolves gold and platinum.

Strong bases dissolve such metals as zinc, aluminium, and tin.

**Effects of the Atmosphere.**—Gold, platinum, silver, and mercury are *not* changed by exposure to pure air. The rest are affected by the constituents of the air, some becoming coated with a layer of oxide, sulphide, or carbonate, which coating prevents further and deeper reaction. An example of this is the tarnishing of silver in air containing some sulphide, the "tarnish" being a layer of silver sulphide ( $\text{Ag}_2\text{S}$ ). In the other metals the action of the atmosphere is continuous, the metals crumbling into a powder, as iron, which "rusts" to oxide of iron ( $\text{Fe}_2\text{O}_3$ ).

**Chemical Combination.**—Chlorine (Cl), bromine (Br), iodine (I), fluorine (F), oxygen (O), and sulphur (S) unite directly with most metals; arsenic (As), phosphorus (P), and carbon (C) with many. The application of heat is necessary to bring about chemical union in many cases.

**Uses.**—*Iron* is the most useful of all metals. It is used in the manufacture of innumerable things, such as steel structures, rails, tools, instruments, armor plate, cutlery, etc. *Copper* is used in the manufacture of electric wires, cartridges, money, alloys, etc. *Tin* is used principally for coating other metals, since it is not

readily affected upon exposure to the air. Ordinary "sheet tin" is sheet iron coated with tin. Pins are brass or iron coated with tin. Pure tin foil is used as a dental filling. *Aluminium* is used in the manufacture of cooking utensils because of its lightness and because it is almost unaffected by the acids found in vegetables and fruits. It is also used in the manufacture of machinery parts. The powdered metal is used in paints. *Zinc* is used in great quantities in the manufacture of brass and for "galvanizing" iron ("Galvanized iron" is iron coated with zinc). It is also used in electric batteries and in the manufacture of dies. *Lead* is employed in the manufacture of lead-pipe, shot, solder, type-metal, and alloys. *Gold* is used for coinage, jewelry, for gilding, and as a dental filling. It is too soft for most purposes, and is therefore alloyed with silver or copper. Its fineness is designated by the term "karat." Twenty-four karat ("24K") means  $\frac{24}{24}$  or 100 per cent. pure gold; fourteen karat ("14K") means  $\frac{14}{24}$  pure gold, etc. *Silver* is used for coinage, jewelry, useful articles, silver-plating, and dental alloys. *Platinum* is used for jewelry, and, because of its high melting-point and chemical inactivity, in the manufacture of crucibles, evaporating dishes, stills, flame-test wires and other chemical apparatus. *Manganese*, *chromium*, and *nickel* are used in the manufacture of steel; *arsenic*, in the manufacture of pigments, fly-paper, and fireworks; *cobalt*, in the manufacture of blue glass and pigments; *bismuth* and *antimony*, in alloys, such as type-metal and dental alloys; *magnesium*, in the manufacture of photographic flash-powders. *Mercury* is used in the manufacture of thermometers, barometers, amalgams, coatings for the backs of mirrors, and in the extraction of gold and silver from their ores. The rest of the metals have no commercial application in the metallic condition.

**Alloys.**—Some metals, when melted together, thoroughly intermix and, on cooling, form a homogeneous, lustrous substance called an "alloy." In general, the melting-point of the alloy is below the average of the melting-points of its constituents. Examples: *Brass*, an alloy of copper and zinc; *solder*, an alloy of tin and lead; *type-metal*, of tin, lead, and antimony; *German*

*silver*, of copper, zinc, and nickel; United States *gold coin*, of gold and copper; United States *silver coin*, of silver and copper.

**Amalgams.**—Amalgams are alloys of mercury with some other metal. Examples: *Mirror amalgam*, mercury and tin; *silver amalgam*, mercury and silver; *gold amalgam*, mercury and gold. All metals form amalgams with mercury except iron and platinum.

**Physiological Effects.**—The metals have little or no action on the body until they are converted into compounds by body juices. The most common metal employed in the metallic condition is *mercury*. This is used in the form of "Gray Powder" (the metal rubbed with chalk), "Mercurial Ointment," and "Blue Ointment" (the metal combined with fatty substances) and "Blue Mass" or "Blue Pill" (the metal mixed with licorice, marshmallow, honey of rose, and glycerine).

**Salts** of *lead*, *iron*, *zinc*, *aluminum*, and *copper* are generally astringent. *Magnesium* salts are antacid and laxative; *bismuth* salts are used as mucous membrane sedatives because they form an insoluble protective coating; *iron* and *arsenic* salts are valuable alteratives and tonics; *calcium* salts, in general, are depressant to the central nervous system, stimulate and strengthen the heart at first, but then depress it; *potassium*, *lithium*, and *strontium* salts depress the central nervous and muscular systems and the heart; *sodium* salts are cathartics and antacids.

**Radium**, **thorium**, **actinium**, and **polonium** are found in **uranium** ores in minute quantities. All of them are called "**radio-active**," since they emit luminous rays which will pass through opaque objects, affect photographic plates, produce electric effects, and which have a decided action on the human body. Minerals, such as pitch-blende, which contain uranium are more radio-active than uranium itself.

YASSEL IMAI

## CHAPTER VII

### THE NON-METALS

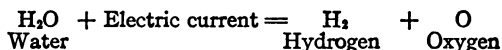
THIS class of elements possesses physical properties that are the reverse of those of the metals, and they are acid forming in character.

#### HYDROGEN

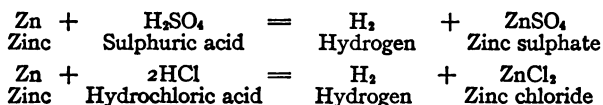
*Symbol, H. Atomic weight, 1. Valence, I.*

The elemental gas hydrogen, although it conducts itself in many respects like a metal, is usually classed with the non-metallic elements for convenience. In the free state it is found *in traces* in the atmosphere; also in volcanic and other natural gases. In the combined condition it is widely distributed, being a constituent of water, acids, bases, most fuels, starch, sugar, as well as all living organisms. About 9 per cent. of the human body is hydrogen.

It may be prepared by the decomposition of water with the electric current.



The usual laboratory method for its preparation is treating granulated zinc with diluted sulphuric or hydrochloric acid.



Hydrogen is a colorless, odorless, tasteless gas, and is the lightest and most diffusible substance known. It can be liquefied to a steel-blue liquid at a temperature of  $-205^\circ \text{C}$ . It becomes solid at  $-256^\circ \text{C}$ . It dissolves in 50 parts of water.

Under ordinary conditions hydrogen shows but little affinity for other substances. At high temperatures it is quite active with oxygen, burning with a pale-blue flame, forming water. If hydro-

gen and oxygen gases are mixed and then ignited, they explode with the production of the same compound (water). It is neither noxious nor beneficial physiologically. It can be inhaled for a short time without injury, but produces a peculiar change in the voice.

Hydrogen is used for filling balloons and as a chemical reagent.

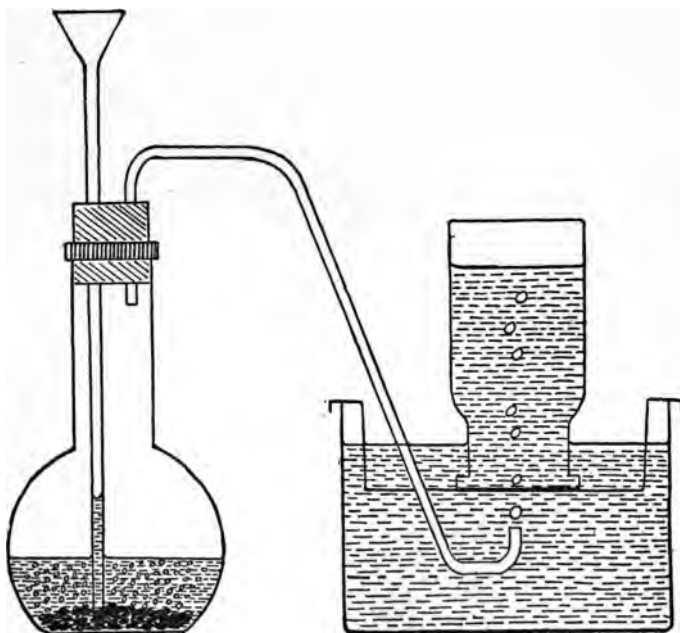


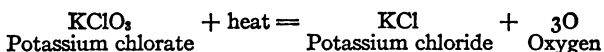
FIG. 36.

**Experiment 8.**—Place about 10 grammes of granulated zinc in a flask fitted with a two-holed rubber stopper; through one hole pass a funnel-tube reaching nearly to the bottom of the flask; through the other hole in the stopper pass a glass tube bent at right angles and leading into a vessel of water as illustrated. Fill a wide-mouth bottle of 300 to 500 Cc. capacity with water, and invert it, still filled with the water, in the vessel of water. The bent tube from the flask should be placed under the mouth of the inverted bottle (Fig. 36). With the apparatus in this condition, pour about 25 Cc. of 10 per cent. sulphuric acid through the funnel-tube. Bubbles of hydrogen gas will immediately rise in the flask and pass over into the bottle, replacing the water therein and filling it with gas. After the bottle has been filled with the gas, remove it, hold it top side up for a few moments, and drop a lighted match in it. An explosion will occur. What is formed?

## OXYGEN

*Symbol, O. Atomic weight, 15.88. Valence, II.*

Oxygen is the most abundant of the elements, forming about one-half of the earth's crust, about one-fifth of the atmosphere, eight-ninths of water, and 72 per cent. of the human body. It is found in the free state in the atmosphere, and in combination in all plants and animals. The gas may be manufactured by strongly heating some potassium chlorate,  $\text{KClO}_3$ :



Or, at a lower temperature, by heating a mixture of potassium chlorate and manganese dioxide,  $\text{MnO}_2$ :



In the latter reaction the manganese dioxide is called a "catalytic agent"; *i.e.*, an agent that favors or assists in a chemical reaction, but which does not appear as one of the new products formed. It remains unchanged. We might compare it to lubricating oil which favors or assists in the motion of machinery.

Oxygen is a colorless, odorless, tasteless gas. It may be liquefied at a temperature of  $-140^\circ \text{C}$ . and a pressure of 300 atmospheres. It is a little more soluble in water than hydrogen. Aquatic animals and plants obtain oxygen necessary for their existence from that found dissolved in water. It is about sixteen times as heavy as hydrogen.

Oxygen is very active, uniting with all elements except fluorine. When the union of oxygen with an element or compound is accompanied by an evolution of light and heat, the process is known as **combustion**; if the reaction is less energetic, no light being evolved, it is called "slow combustion" or **oxidation**. Those substances which are easily oxidized are called "combustible." They are composed mainly of hydrogen and carbon, with which the oxygen unites, forming water and carbon dioxide,  $\text{CO}_2$ .



Oxygen is essential to the life of plants and animals. An adult consumes about two pounds daily. Animals use more oxygen than plants. Plants give off more oxygen than they use. However, animals exhale carbon dioxide, which is made use of by plants. The carbon dioxide and water given off by the lungs are produced by the oxidation of the tissues by means of the oxygen inhaled and carried throughout the body by the blood.

The gas is extensively used as an inhalant for stimulating the action of the heart in diseases of the lungs, in dangerous chloroform narcosis, and poisoning by coal gas.

**Experiment 9.**—Mix well 5 grammes of potassium chlorate and manganese dioxide and evenly distribute the mixture on the side of a horizontal test-tube fitted with a one-hole stopper and glass tube as in the case of the hydrogen experiment. Collect a bottle of oxygen gas, place it right side up, covering the mouth of the bottle with a wet paper. Insert a dry, unlighted taper. No activity is noticed. Then insert a glowing stick and note the rapid burning which ensues. This illustrates the activity of oxygen at higher temperatures.

### OZONE

*Formula,  $O_3$ . Molecular weight, 47.64.*

Ozone is a peculiar form of oxygen found in small quantities in the air, especially after thunder-storms, and in the region of electrical machinery. It is colorless, and has a peculiar odor. Its properties are practically the same as those of ordinary oxygen, but it is much more active chemically.

## THE HALOGENS

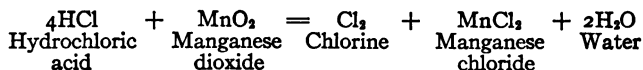
This group is composed of the elements **chlorine, bromine, iodine, and fluorine**. They are known as "halogens" because of their salt-forming properties. They can be derived from seawater and sea-plants. All members of the group have sharp, acrid tastes and characteristic odors. They are corrosive and are employed as bleaching and disinfecting agents.

### CHLORINE

*Symbol, Cl. Atomic weight, 35.18. Valence, I, III, V, VII.*

Chlorine never occurs in nature in the free state, but is widely distributed in combination as chlorides, common salt (sodium chloride,  $NaCl$ ) being the most abundant.

A laboratory method for its preparation is the oxidation of hydrochloric acid:



Chlorine is a gas having a greenish-yellow color, a penetrating, suffocating odor, and an acid taste. It is heavier than air, and dissolves readily in water. The solution of chlorine gas in water is known as "Chlorine Water."

Chemically, chlorine is very active, especially with the metallic elements and hydrogen. In the presence of water, chlorine is an active bleaching agent, because of the oxygen gas that is liberated through the decomposition of the water. For this reason it is also a good disinfectant.

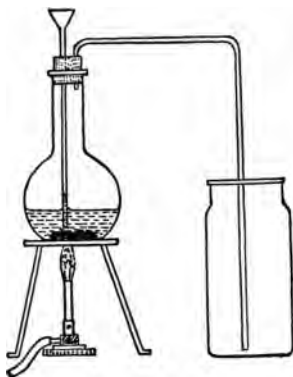


FIG. 37.

**Experiment 10.**—Place 10 grammes of manganese dioxide in the flask used for the hydrogen experiment and lead the delivery tube into a dry bottle, right side up. Have the tube extend to the bottom of the bottle. Add 25 Cc. of hydrochloric acid to the manganese dioxide and warm (Fig. 37). Chlorine gas is liberated, and, since it is greenish-yellow, one may easily tell when the bottle is full of the gas. [Caution:—Do not breathe the gas, as it is very irritating to the mucous membranes of the

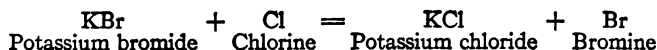
nose and throat.] Place a red or other colored flower in the bottle and note the bleaching effect of the gas. Repeat with a small piece of damp, colored calico.

### BROMINE

*Symbol, Br. Atomic weight, 79.34. Valence, I, III, V, VII.*

Bromine does not occur in the free state in nature, but is found in combination, as bromides, along with the chlorides.

The element may be liberated from its compounds, the bromides, by treating a solution of a bromide, like potassium bromide (KBr), with chlorine gas. The chlorine, because of its greater affinity for the metal, replaces the bromine, as shown in the following equation:



Bromine is a caustic, reddish-brown, fuming liquid, having an odor resembling that of chlorine. It is heavier than water, and dissolves in twenty-eight parts of the solvent, the solution being known as "Bromine Water." It is more soluble in chloroform, ether, and carbon disulphide.

Although bromine is quite energetic, it is less active than chlorine, but is more active than the next member of the group, iodine. Its chemical properties are very similar to those of chlorine.

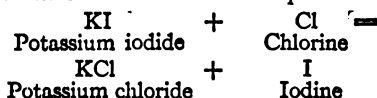
The chief use of the element is in the manufacture of the bromides, although it is a disinfectant.

### IODINE

*Symbol, I. Atomic weight, 125.89. Valence, I, III, V, VII.*

Iodine occurs in combination in the ashes of sea-weed and in the mineral "Chili-saltpetre" ( $\text{NaNO}_3$ ), never in the free state.

It may be liberated from its compounds the iodides. Example:



It comes in the form of bluish-black, volatile plates, with a metallic lustre, a characteristic odor, and a sharp, acrid taste. It is about five times as heavy as water. Upon heating, it is converted to violet vapors. The element is slightly soluble in water, readily soluble in alcohol, ether, chloroform, carbon disulphide, and aqueous solution of potassium iodide. *Tincture of Iodine* is an alcoholic solution containing about 7 per cent. of iodine and 5 per cent. of potassium iodide.

Although it attacks some metals, it is the least energetic of this group. Solutions of iodine should not be handled in silver spoons, since it attacks this metal. It stains the skin brown. Starch paste is turned blue by free iodine.

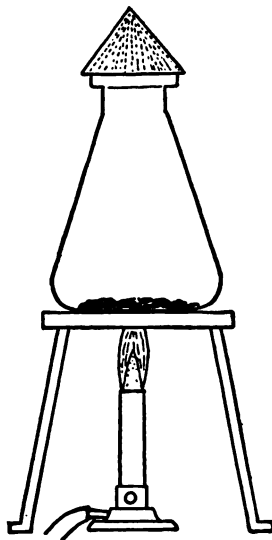


FIG. 38.

Its use in medicine is that of an antiseptic and disinfectant.

**Experiment 11.**—Place about 3 grammes of potassium iodide, an equal quantity of manganese dioxide, and 15 Cc. of 50 per cent. sulphuric acid into a small Erlenmeyer flask and mix well. Fold a small filter paper as for a funnel, wet it with cold water and place it, point up, over the mouth of the flask (Fig. 38). Warm the flask gently. The iodine will be deposited on the inside surface of the filter paper as thin plates. Test its solubility in alcohol and water.

### FLUORINE

*Symbol, F. Atomic weight, 19.0. Valence, I.*

Fluorine occurs in combination in certain minerals, sea-water, mineral waters, bones, teeth, and milk.

It is a yellowish gas with a penetrating odor, and is the most active of all known elements. It is prepared by electrolytic processes, and must be kept in vessels of gutta-percha, platinum, or gold.

### NITROGEN

*Symbol, N. Atomic weight, 13.93. Valence, III, V.*

In the free state nitrogen constitutes about four-fifths of the atmosphere. It occurs in combination in many minerals, all animal substance, and forms a component of the products of animal decay.

Nitrogen is a colorless, odorless, tasteless gas, a little lighter than air. It is slightly soluble in water. Nitrogen does not burn or support combustion. It is chemically inert. Its compounds are unstable and, upon decomposition, often explode, as in nitroglycerin. Many very poisonous compounds contain nitrogen, such as the cyanides. The gas itself is non-poisonous and simply acts as a diluent for the oxygen in the air, without which, oxidation processes in the body would be far too rapid.

### THE ATMOSPHERE

The atmosphere is a *mechanical mixture* of gases and forms the aerial envelope of the earth. The average composition of dry air is as follows:

Nitrogen.....	78.10
Oxygen.....	21.00
Argon.....	0.90
Helium, neon, krypton, xenon, carbon dioxide, and hydrogen...	traces

The nitrogen serves as a diluent for the life-sustaining oxygen. The oxygen supports life, combustion, and oxidation, and remains practically constant, due to liberation of oxygen from plants. Carbon dioxide is found in variable quantities, since it is a product of combustion, fermentation, decay, and respiration. It averages about 0.04 per cent., but is higher in cities. In living-rooms it should not rise above 0.1 per cent. Another variable constituent of the atmosphere is *moisture*. The rare gases helium, neon, krypton, and xenon, as well as hydrogen, occur only in traces.

Air may be liquefied on a commercial scale by machinery. When in the liquid state it is faintly blue and begins to boil at  $-190^{\circ}\text{C}$ . It freezes metallic mercury. It has been used to a limited extent in medicine as a caustic and as a local anæsthetic.

### SULPHUR

*Symbol, S. Atomic weight, 31.83. Valence, II, IV, VI.*

Sulphur was one of the elements known to the ancients. It occurs in the free state in very large quantities, especially in the neighborhood of volcanoes. It also occurs in combination as sulphides and sulphates.

It is extracted from native sulphur by fusion and subsequent sublimation.

Sulphur is a lemon-yellow, brittle, crystalline solid, odorless and almost tasteless. Its specific gravity is 2.05. It is insoluble in water, but readily dissolves in carbon disulphide, turpentine, fixed oils, etc. It melts at  $114.5^{\circ}\text{C}$ . The melted liquid is first straw-yellow, but becomes dark red and viscid when heated to about  $250^{\circ}\text{C}$ .; then it becomes too thick to pour and almost black in color. When heated to the boiling-point,  $448.4^{\circ}\text{C}$ ., it becomes thin again, but remains dark in color. It exists in an amorphous form and two different crystalline forms.

**Experiment 12.**—Slowly heat some sulphur in a dry test-tube until it boils, noting the various changes already described. Then pour out the melted substance into a dish of cold water. Examine the mass in the dish. Also examine the remains in the test-tube.

The commercial forms of sulphur are: (a) roll sulphur or brimstone, a crude, moulded form used for commercial purposes

only; (b) **flowers of sulphur** or **sublimed sulphur** ("Sulphur Sublimatum"), prepared by allowing the vapors of sulphur to cool in cold chambers; (c) **washed sulphur** ("Sulphur Lotum"), prepared by washing sublimed sulphur with a diluted solution of ammonia gas; (d) **precipitated sulphur** ("Sulphur Præcipitatum") or **milk of sulphur**, prepared by boiling together sulphur, slaked lime, and water, and then adding to this solution of sulphur, hydrochloric acid, which precipitates the sulphur.

Sulphur burns with a blue flame, giving off suffocating fumes of sulphur dioxide ( $\text{SO}_2$ ). It combines with most of the metals and non-metals.

It is used for vulcanizing, in the manufacture of gunpowder and fireworks, and in medicine as a laxative and parasiticide.

### PHOSPHORUS

*Symbol, P. Atomic weight, 30.75. Valence, III, V.*

Phosphorus is never found in the free state in nature. Its principal occurrence is in combination as a phosphate in minerals and bones, from which it is prepared.

It occurs in a number of different forms, the principal ones being those known as the **red** and the **yellow** varieties.

**Yellow phosphorus** occurs in the form of a waxy, translucent solid with a garlic-like odor. Specific gravity, 1.83. It melts at  $44^\circ \text{C}$ . It is insoluble in water, but is quite soluble in chloroform, carbon disulphide, and oils. It unites very readily with oxygen, and therefore must be kept under water to prevent combustion. The slow oxidation of phosphorus is accompanied by a glowing which is known as "phosphorescence." It unites directly with all elements except nitrogen and carbon.

**Red phosphorus**, also known as "amorphous phosphorus," may be prepared from the yellow by heating to  $300^\circ \text{C}$ . in air-tight vessels. Its specific gravity is 2.14. It is reconverted to ordinary yellow phosphorus by heating to  $260^\circ \text{C}$ . It is stable in air, does not phosphoresce, and is insoluble in carbon disulphide and other solvents. Red phosphorus is much more inert than the yellow variety.

The *yellow* variety is very poisonous, although the *red* is comparatively non-toxic because of its insolubility. Yellow phosphorus is used in medicine for building up bony and nervous tissues. It is also used as a rat poison. The red variety is used in the manufacture of matches.

**Experiment 13.**—Place a small piece of phosphorus, a piece about the size of a pea, in a dry dish in a moderately warm room and watch the result after a few minutes. The burning of the phosphorus shows its great affinity for oxygen. The white fumes given off consist of phosphorus pentoxide ( $P_2O_5$ ).

### BORON

*Symbol, B. Atomic weight, 10.9. Valence, III.*

Boron does not occur in the free state, but is found natively as borax ( $Na_2B_4O_7$ ) and boric acid ( $H_3BO_3$ ).

It may exist as a brown or yellow, amorphous powder, or in the form of infusible crystals. The crystalline variety possesses a degree of hardness which stands next to that of the diamond.

### SILICON

*Symbol, Si. Atomic weight, 28.2. Valence, IV.*

Next to oxygen, silicon is the most abundant of the elements. It is never found free, but occurs combined in nearly all rocks and soil, as well as in plant and animal life.

It is a dark, lustrous, hard solid, with a specific gravity of 2.5. It exists in both amorphous and crystalline forms.

### CARBON

*Symbol, C. Atomic weight, 11.9. Valence, IV.*

Carbon occurs abundantly both in the free and combined condition. In the free state it is found in three forms: (a) *amorphous*, (b) *graphite*, (c) *diamond*.

**Amorphous** carbon includes coke, wood charcoal, animal charcoal, and lampblack. *Coke* is the non-volatile residue left in the manufacture of illuminating gas from coal. It occurs as an irregular, brittle, porous, grayish, lustrous solid. *Wood charcoal*, usually called simply "charcoal," is obtained by burning wood with little air. It is a black, porous solid without odor or

taste. *Animal charcoal* or "bone-black" is prepared by the destructive distillation of bones. *Lampblack* is prepared through the ignition of compounds rich in carbon and yielding smoky flames, like resins.

**Graphite**, called "plumbago" or "black lead," occurs as a native, crystalline variety, and is also made from amorphous carbon by means of the electric current. It occurs in the form of friable, black, metallic-like masses. When rubbed between the fingers a greasy feeling is experienced, and it leaves a black line when run over paper.

**Diamond** is the hardest known substance. Its specific gravity is 3.5. It crystallizes in cubes. When diamonds are found they are covered with an opaque layer, which is removed when the gem is cut and polished. The brilliancy of the diamond depends upon the high refraction of light and the large number of reflecting surfaces. Microscopic diamonds are sometimes found in steel.

At high temperatures all varieties of carbon unite with oxygen of the air to form carbon dioxide ( $\text{CO}_2$ ). Carbon is practically inactive with all other substances at ordinary temperature.

Coke and charcoal are used as fuel. Lampblack is used as a paint pigment. Animal charcoal is used as a deodorizer and decolorizer. Graphite is employed in the manufacture of lead pencils, anti-friction compounds, paint, glazing, and electrotyping. Diamonds are worn as gems; small imperfect ones are used in glass-cutters and drills.

**Coal** contains carbon, oxygen, hydrogen, nitrogen, mineral matter, and frequently sulphur. There are two kinds: *Anthracite* and *Bituminous*. The *former* is *hard*, and contains about 90 per cent. of carbon and very little sulphur. It burns with little flame and gives out an intense heat. There is but from 6 to 7 per cent. of volatile matter in it. The *latter* is softer and contains from 10 to 30 per cent. of volatile matter.



# INORGANIC COMPOUNDS

## CHAPTER VIII

### ACIDS

THIS class of compounds is usually strongly acid in reaction, reacts with metals and bases to form salts, has a sour taste, and contains hydrogen as one constituent. Some give off fumes at ordinary temperature, such as hydrochloric, nitric, and hydriodic acids (HCl, HNO<sub>3</sub>, HI). They owe their physiological action to the hydrogen atoms they contain. Upon coming in contact with organic tissue they abstract water, coagulate the proteids of the skin, and give rise to numbness and a stiff, puckery feeling. In fevers they are employed internally, in much *diluted* condition, to diminish thirst, because they stimulate the flow of saliva and other alkaline fluids. They are excreted from the body chiefly as ammonium salts. When administered in large doses or when in undiluted condition they are caustic protoplasmic poisons.

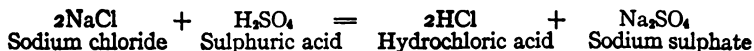
### THE HALOGEN ACIDS

These are colorless gases with sharp, irritating odors and acid tastes. All are monobasic.

#### HYDROCHLORIC ACID (HCl)

##### "Muriatic Acid"

This is the most important of the halogen acids. It is found free in the atmosphere about volcanoes, and in human gastric juice. It may be prepared by the action of sulphuric acid on sodium chloride:



It is a colorless gas, with a sharp, irritating odor and acid taste. It is heavier than air and very soluble in water. One volume of water dissolves 505 volumes of the gas. This solution is com-

mercially known as "Concentrated Hydrochloric Acid." The yellow color that some samples of this acid possess is due to the presence of iron. The official diluted hydrochloric acid should contain 10 per cent. of the gas.

With metals and bases it gives rise to the formation of a class of salts called "chlorides," such as sodium chloride, NaCl (common salt); potassium chloride, KCl; calcium chloride, CaCl<sub>2</sub>; ammonium chloride, NH<sub>4</sub>Cl.

Hydrochloric acid may be identified by the white fumes (ammonium chloride, NH<sub>4</sub>Cl) that appear when a rod, moistened with ammonia water, is brought over the mouth of the bottle containing it.

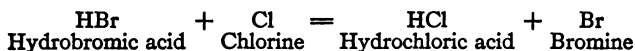
It is used in medicine to replace deficiency in the normal acidity of the stomach, and as an antiseptic to prevent certain forms of fermentation in the stomach.

**Experiment 14.**—Place 10 grammes of sodium chloride in a flask fitted with a two-holed rubber stopper and carrying a funnel tube and a bent glass tube leading into a dry bottle. Through the funnel tube pour about 10 Cc. of sulphuric acid and warm the flask. Hydrochloric acid gas is liberated. *Cautiously* note the odor. *Do not inhale the undiluted gas!* The solubility of the gas may be easily shown by pouring a small quantity of water into the bottle, holding the palm of the hand firmly over its mouth, and shaking. The gas will be dissolved by the water, creating a suction on the palm of the hand. Hold a rod moistened with ammonia water over the bottle and note result.

### HYDROBROMIC ACID (HBr)

Hydrobromic acid is a heavy, colorless gas with a sharp, irritating odor and an acid taste. It is very soluble in water (600 to 1). The official diluted hydrobromic acid contains 10 per cent. of the acid.

Chlorine decomposes the acid according to the following equation:



Its salts are known as "bromides," such as sodium bromide (NaBr).

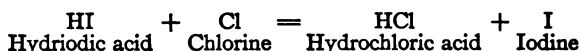
When heated with strong sulphuric acid, the acid gives off reddish fumes.

It is used as a sedative and to allay coughs.

**HYDRIODIC ACID (HI)**

This is also a colorless, heavy gas, with a sharp, irritating odor and an acid taste. It is very soluble in water (425 to 1). The official diluted acid contains 10 per cent. of the acid, and the syrup 1 per cent.

Chlorine decomposes it according to the following equation:



Its salts are known as "iodides," such as potassium iodide (KI).

The acid may be detected by adding some chlorine water and starch paste, when a blue color will appear.

It is used in the treatment of asthma, syphilis, and some skin diseases.

**HYDROFLUORIC ACID (HF)**

Hydrofluoric acid is a colorless gas, which liquefies to a colorless liquid at 19.4° C. It reacts with glass, its effect being known as "*etching*." For this reason it must be kept in gutta-percha or wax bottles. It is very caustic, and, when brought in contact with the skin, produces slow-healing ulcers.

Its salts are known as "fluorides," as sodium fluoride (NaF).

Its principal use is in the etching of glassware.

**THE SULPHUR ACIDS****SULPHUROUS ACID (H<sub>2</sub>SO<sub>3</sub>)**

This acid is not known in the free state, but occurs in solution in water. It may be manufactured by passing sulphur dioxide (SO<sub>2</sub>) into water.



It is dibasic. The official acid is a colorless liquid, with a sulphurous odor and an acid, sulphurous, astringent taste. It should contain 6 per cent. of sulphur dioxide gas.

Its salts are known as "sulphites," as sodium sulphite (Na<sub>2</sub>SO<sub>3</sub>).

It is used as a bleaching agent, for removing fruit-juice stains from linen, and as a disinfectant.

**SULPHURIC ACID ( $\text{H}_2\text{SO}_4$ )***"Oil of Vitriol"*

Sulphuric acid is the most important and powerful of the mineral acids. It is found in springs and rivers that find their origin in volcanic regions. In combination it is found as sulphates.

The acid is prepared by a process known as "The lead chamber process," and also by the more modern "Contact process," in which finely-divided metallic platinum is used as a "catalytic agent."

The concentrated acid is a colorless, odorless, oily, very corrosive liquid having a specific gravity of 1.84. The official diluted acid should contain 10 per cent. of the compound. It has a great attraction for water and breaks up organic matter containing hydrogen and oxygen, removing these elements in the form of water. The carbon of the compounds is left behind, giving the residue a black color. This is known as the "charring" action of this acid.

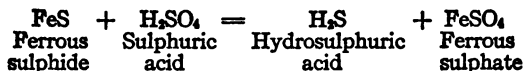
The salts of this acid are known as "sulphates." Since the acid is dibasic, it may form acid and double as well as neutral salts. Examples:  $\text{Na}_2\text{SO}_4$ , sodium sulphate;  $\text{NaHSO}_4$ , sodium acid (bi- or hydrogen) sulphate;  $\text{NaKSO}_4$ , sodium potassium sulphate.

It is used principally in chemical industry and manufacture.

**HYDROSULPHURIC ACID ( $\text{H}_2\text{S}$ )***"Sulphuretted Hydrogen"      "Hydrogen Sulphide"*

This acid occurs in volcanic gases, mineral waters, and as a product of animal decomposition.

The acid may be prepared by treating a sulphide with diluted sulphuric or hydrochloric acid.



It is a colorless gas, with an odor of rotten eggs and a sweetish taste. It is soluble in water, heavier than air, and burns with a pale-blue flame. If the gas is inhaled in the undiluted condition, it acts as a violent poison. Even in diluted condition it causes

nausea, headache, and dizziness. It tarnishes silverware, forming a black layer of silver sulphide ( $\text{Ag}_2\text{S}$ ). Its salts are known as "sulphides," such as ferrous sulphide ( $\text{FeS}$ ). It is used as a chemical reagent in the laboratory.

## THE NITROGEN ACIDS

### NITROUS ACID ( $\text{HNO}_2$ )

Nitrous acid is a very unstable, blue liquid, made by passing nitrogen trioxide ( $\text{N}_2\text{O}_3$ ) into ice water.

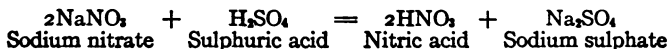


Its salts are known as "nitrites," as sodium nitrite ( $\text{NaNO}_2$ ).

### NITRIC ACID ( $\text{HNO}_3$ )

*"Aqua Fortis"*

This acid is not found in the free condition, but occurs in combination as nitrates. It may be prepared by treating a nitrate with sulphuric acid.



Nitric acid is a colorless, fuming, very corrosive liquid, having a specific gravity of 1.5. It is quite soluble in water. The official diluted acid should contain 10 per cent. of the acid.

It readily yields up its oxygen, and is therefore known as a strong "*oxidizing agent*." When it comes in contact with organic tissue it stains it yellow. The reaction may be used as a test for the acid. Upon standing the acid becomes yellow because of decomposition.

Its salts are known as "nitrates," such as potassium nitrate ( $\text{KNO}_3$ ).

It is used externally as an irritant and caustic, and in metallurgy and the manufacture of explosives and dyes.

**Experiment 15.**—Place 10 grammes of sodium nitrate in a flask fitted as for hydrochloric acid, and add some sulphuric acid. Warm the mixture. Nitric acid will be formed. Note its fuming property and its effect upon the skin.

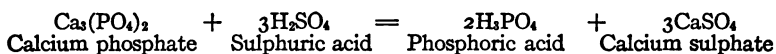
**NITROHYDROCHLORIC ACID***" Aqua Regia "*

This acid is also known as " nitromuriatic acid," and is prepared by mixing nitric and hydrochloric acids (18 Cc. to 82 Cc.). No chemical formula is assigned this mixture, since an indefinite chemical reaction takes place when the acids are mixed. It is a golden-yellow, fuming, very corrosive liquid, with a strong odor of chlorine. It readily dissolves gold and platinum.

The diluted acid is used internally like hydrochloric.

**THE PHOSPHORUS ACIDS****(ORTHO) PHOSPHORIC ACID ( $H_3PO_4$ )**

This acid does not occur in the free state in nature, but exists in combination as phosphates. It may be made by treating calcium phosphate with sulphuric acid.



It is a crystalline solid, but upon exposure to air it takes up water, forming a thick, syrupy liquid. It is tribasic. The official acid should contain 85 per cent. of the acid, and the diluted variety, 10 per cent.

Its salts are known as "phosphates." Examples:  $\text{Na}_3\text{PO}_4$ , neutral or tri-sodium phosphate;  $\text{Na}_2\text{HPO}_4$ , acid or di-sodium phosphate (the official salt);  $\text{NaH}_2\text{PO}_4$ , acid or mono-sodium phosphate.

It is used in the treatment of dyspepsia and as an astringent and stimulant.

**HYPOPHOSPHOROUS ACID ( $\text{H}_2\text{P}_2\text{O}_5$ )**

This acid is a crystalline solid, which melts at  $17.4^\circ \text{C.}$  to a colorless, thick liquid having an acid taste and no odor. The official diluted hypophosphorous acid contains 10 per cent. of the acid. It is monobasic.

Its salts are known as "hypophosphites," as  $\text{NaPH}_2\text{O}_2$ , sodium hypophosphite.

It is used as a stimulant and tonic.

## THE ARSENIC ACIDS

### ARSENOUS ACID ( $\text{H}_3\text{AsO}_3$ )

This acid is not known in the free state, for upon liberating it from its salts it breaks up into arsenic trioxide ( $\text{As}_2\text{O}_3$ ) and water ( $\text{H}_2\text{O}$ ). It is tribasic.

Its salts are known as "arsenites," as sodium acid arsenite ( $\text{Na}_2\text{HAsO}_3$ ).

### ARSENIC ACID ( $\text{H}_3\text{AsO}_4$ )

Arsenic acid is a white, deliquescent, crystalline solid, which corrodes and blisters the skin. It is tribasic. Its salts are known as "arsenates," as sodium acid arsenate ( $\text{Na}_2\text{HAsO}_4$ ).

It is used in manufacture, especially the manufacture of the arsenates.

---

### HYDROCYANIC ACID ( $\text{HCN}$ )

#### "Prussic Acid"

Hydrocyanic acid is produced by the action of the ferment "emulsin" on the glucoside "amygdalin" in the presence of water. These substances occur in peach kernels, bitter almonds, cherry laurel bark, wild cherry bark, etc.

It is a colorless, volatile liquid, with an odor of peach blossoms. It is soluble in water. The official diluted acid contains 2 per cent. of the acid, and is given in very small doses.

Its salts are known as "cyanides," as potassium cyanide ( $\text{KCN}$ ).

*This acid is one of the most rapidly acting and deadly of all poisons!* It quickly paralyzes the heart and respiration. In medicine it is used as an antispasmodic, analgesic, anti-emetic, and to relieve itching. Because of the rapidity of its action, antidotes are extremely unsatisfactory.

### CARBONIC ACID ( $\text{H}_2\text{CO}_3$ )

Carbonic acid is not known in the free state, since it readily breaks up with the formation of carbon dioxide ( $\text{CO}_2$ ) and water ( $\text{H}_2\text{O}$ ). It is dibasic.

Its salts are known as "carbonates," such as sodium carbonate ( $\text{Na}_2\text{CO}_3$ ), sodium bicarbonate ( $\text{NaHCO}_3$ ), etc.

**BORIC ACID ( $H_3BO_3$ )***" Boracic Acid "*

Boric acid occurs in the free state, especially in the region of volcanoes. It occurs in the form of transparent, colorless, pearly scales, or as a white powder with a soapy feeling when rubbed between the fingers. It has a faintly bitterish taste, but no odor. It is soluble in about 20 parts of water.

It is a non-toxic, non-irritating antiseptic, used especially as a wash for the nose, throat, mouth, rectum, vagina, ear, etc.



## CHAPTER IX

### BASES

THESE compounds are often called "*hydroxides*," and the more caustic ones are known as "*alkalis*," among which are potassium, sodium, calcium, and ammonium hydroxides ( $\text{KOH}$ ,  $\text{NaOH}$ ,  $\text{Ca}(\text{OH})_2$ ,  $\text{NH}_4\text{OH}$ ). They are chiefly white, crystalline, deliquescent solids (except ammonium hydroxide, which is a liquid), with a caustic, alkaline taste, turn red litmus blue, and form salts with acids. The alkali hydroxides dissolve proteins, soften the skin, remove the horny layers of epithelium, saponify fats, and render the blood and tissues more alkaline, aiding oxidation. Ammonium hydroxide, because of its being volatile, is more penetrating, but is less caustic. When given internally in large doses or in the undiluted condition, they are intense, caustic poisons.

#### POTASSIUM HYDROXIDE ( $\text{KOH}$ )

" *Caustic Potash* "      " *Potassium Hydrate* "

Potassium hydroxide is prepared commercially by an electrolytic method. When pure, it is a white, crystalline, brittle solid without odor, but having a sharp, caustic taste. It is very soluble in water and alcohol. Upon exposure to air it absorbs carbon dioxide and water. The official solution of potassium hydroxide should contain about 5 per cent. of the compound dissolved in water. The commercial compound is in the form of white, opaque, moulded sticks, and is from 75 to 90 per cent. pure. It should not be handled with the fingers, because of its caustic action on animal tissues, and should be kept in tightly-stoppered bottles.

It is used externally as a caustic for removing warts, etc. It is also used in large quantities in the manufacture of *soft* soap.

**SODIUM HYDROXIDE (NaOH)**

“ *Caustic Soda* ”      “ *Sodium Hydrate* ”

This compound is commercially prepared by a method similar to that used in the manufacture of potassium hydroxide. The commercial form, when pure, occurs as brittle, white, opaque, crystalline, odorless sticks, having a caustic taste. It is very soluble in both water and alcohol. Upon exposure, it absorbs water and carbon dioxide from the air. The official solution should contain about 5 per cent. of sodium hydroxide. Because of its caustic effect, it should not be handled with the fingers. The compound should be kept in tightly-stoppered bottles.

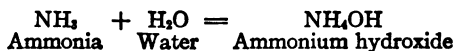
It is used as a caustic and also in the manufacture of *hard* soaps.

**AMMONIUM HYDROXIDE (NH<sub>4</sub>OH)**

“ *Ammonia Water* ”

Ammonium hydroxide is prepared by passing “*ammonia*” gas into water. **Ammonia** is a compound of hydrogen and nitrogen, and has the formula, NH<sub>3</sub>. It is a colorless gas with a sharp, burning taste and a pungent, penetrating odor. It turns red litmus paper blue and forms salts with acids. It is a product of vegetable and animal decay, and occurs in the air in minute quantities. The gas is used in refrigerating plants.

When the gas is dissolved in water, **ammonium hydroxide** is formed, according to the following equation:



The *radical*, NH<sub>4</sub>, is called “**ammonium**,” and conducts itself in chemical reactions like a metal.

Aqueous solution of ammonia is official in two strengths: *Ammonia Water*, containing 10 per cent. of the gas, and *Stronger Ammonia Water*, containing 28 per cent. *Spirit of Ammonia* is an alcoholic solution containing 10 per cent. of the gas, and *Aromatic Spirit of Ammonia*, containing ammonia water, ammonium car-

bonate, alcohol, and oils of lemon, nutmeg, and lavender flowers, is also official.

Ammonia and its compounds are stimulant to both respiration and circulation. When applied externally the gas is an irritant.

### CALCIUM HYDROXIDE ( $\text{Ca}(\text{OH})_2$ )

#### "Slaked Lime"

When lime (calcium oxide,  $\text{CaO}$ ) is treated with water the substances combine chemically with the liberation of much heat, forming calcium hydroxide.



The product resulting from the above reaction is a fine, white, impalpable powder, slightly soluble in water. When the compound is mixed with water it forms what is commonly known as "*milk of lime*," which contains an excess of calcium hydroxide and, when shaken, has a milky appearance, due to the excess of undissolved, suspended hydroxide.

A saturated solution of calcium hydroxide in water is known as "*lime water*," a colorless, odorless liquid with a feebly caustic, saline taste and alkaline reaction. On boiling it becomes turbid, owing to the lesser solubility of the compound in hot water.

Lime water is used in medicine as an antacid, to furnish bone salts to the tissues, and as an astringent. It is frequently added to cow's milk to lessen its acidity, so as to prevent curdling and to assist in its ready digestion. Lime ( $\text{CaO}$ ), internally, is a gastrointestinal irritant. It is used as a disinfectant for cesspools, etc.

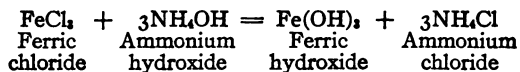
### MAGNESIUM HYDROXIDE ( $\text{Mg}(\text{OH})_2$ )

This compound occurs in small quantities in nature. It may be prepared by heating a mixture of magnesium oxide,  $\text{MgO}$  ("*magnesia*"), and water. It is a white, odorless, nearly insoluble powder. When mixed with water in the proportion of 1 to 15 it forms a white, gelatinous mixture, called "*milk of magnesia*," which is used in medicine as a mild laxative.

**FERRIC HYDROXIDE** ( $\text{Fe}(\text{OH})_3$ )

*"Iron Hydroxide"*      *"Iron Magma"*

Ferric hydroxide is a reddish-brown magma, and may be prepared by precipitation of ferric chloride ( $\text{FeCl}_3$ ) by ammonium hydroxide ( $\text{NH}_4\text{OH}$ ).



It is frequently used, along with magnesium oxide, as an antidote in arsenical poisoning.

## CHAPTER X

### SALTS

A **salt** has already been defined as a substance resulting from the action of an acid on a base or metal. They usually produce no change in litmus; *i.e.*, are "neutral in reaction." Neutral, acid, double, and basic salts are used extensively in medicine.

### THE HALOGEN SALTS

Most of the halogen salts are white in color, have a sharp, saline, bitter taste, do not affect litmus, are crystalline in structure, freely soluble in water (except the halogen salts of mercury (*ous*), silver, and lead), and less soluble in alcohol.

### CHLORIDES

These compounds are salts of hydrochloric acid.

#### SODIUM CHLORIDE (NaCl)

*"Common" or "Table Salt"*

This is the most abundant salt in nature, occurring in all waters and soils. It is obtained from salt-wells and sea-water. It occurs as a white, crystalline, odorless powder, with a saline taste. It is very soluble in water. An aqueous solution of sodium chloride containing 0.6 or 0.9 per cent. of the compound (*same as in blood*) is called "*normal saline solution*," and is used by injection under the skin, into the rectum, or into a vein in cases of hemorrhage, shock, or collapse. Beside its medicinal uses, it is used as a condiment and preservative.

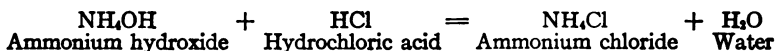
#### POTASSIUM CHLORIDE (KCl)

Potassium chloride is very similar to sodium chloride, and is used principally in the manufacture of fertilizers.

**AMMONIUM CHLORIDE (NH<sub>4</sub>Cl)**

*"Sal Ammoniac"*      *"Ammonium Muriate"*

This salt may be prepared by saturating ammonia water with hydrochloric acid and carefully evaporating the resulting mixture to dryness, avoiding excessive heat.



It occurs either in the form of long, fibrous crystals or as a white, crystalline powder. It is odorless, has a cooling, saline taste, and is quite soluble in water.

In medicine it is used as a stimulant and expectorant. It is also used in the arts in calico-printing, dyeing, soldering, and in refining gold, also in electric batteries.

**CHLORIDES OF MERCURY**

The halogens form two series of compounds with **mercury**, which has a valence of I and II. They are known respectively as **mercurous compounds** (valence I) and **mercuric compounds** (valence II).

**MERCUROUS CHLORIDE (HgCl)**

*"Calomel"*      *"Mild Chloride of Mercury"*

This is a white, odorless, tasteless, impalpable powder, insoluble in water and alcohol.

It is used in medicine as a purgative and antisyphilitic.

**MERCURIC CHLORIDE (HgCl<sub>2</sub>)**

*"Corrosive Sublimate"*      *"Corrosive Chloride of Mercury"*  
*"Bichloride of Mercury"*      *"Bichloride"*

This salt occurs in the form of white crystals which are odorless, and have a sharp, metallic taste. It is soluble in 16 parts of cold water.

The compound is extensively employed as an antiseptic, disinfectant, and antisyphilitic. Internally it acts as a powerful poison, except in very small doses. The best antidote is the raw whites of eggs. (Avoid excess.)

**Test for Chlorides.**—Silver nitrate (AgNO<sub>3</sub>) in the presence of nitric acid (HNO<sub>3</sub>) gives a white, curdy precipitate of silver chloride (AgCl).

**CHLORATES**

**Potassium Chlorate** ( $\text{KClO}_3$ ), "*Chlorate of Potash*"

**Sodium Chlorate** ( $\text{NaClO}_3$ ), "*Chlorate of Soda*"

These salts occur as colorless, odorless, crystalline solids, with cooling, saline tastes. They are soluble in water, and should not be rubbed with sugar, sulphur, or organic substances, as violent explosions may occur, due to oxidation.

Solutions of the salts are used as antiseptic mouth-washes and throat sprays. The salts are also used in the manufacture of matches, explosives, flash powders, and colored fires.

**Test for Chlorates.**—The addition of hydrochloric acid ( $\text{HCl}$ ) to a chlorate produces the liberation of chlorine gas, which may be recognized by its odor, color, and bleaching action.

**HYPOCHLORITES**

**Sodium Hypochlorite** ( $\text{NaClO}$ )      **Potassium Hypochlorite** ( $\text{KClO}$ )

**Calcium Hypochlorite** ( $\text{Ca}(\text{ClO})_2$ )

**Sodium hypochlorite** occurs only in solution as "solution of chlorinated soda" ("*Labarraque's Solution*"), which is used as a disinfecting and bleaching agent.

**Potassium hypochlorite** occurs in a similar solution, known as "*Javelle Water*," and is used for the same purposes.

**Calcium hypochlorite**, commercially known as "chlorinated lime" or "bleaching powder," contains some calcium chloride ( $\text{CaCl}_2$ ), and is used as a disinfectant and bleaching agent.

All hypochlorites, upon exposure to the air or the addition of an acid, liberate chlorine gas.

**BROMIDES**

Salts of hydrobromic acid are called "bromides."

**SODIUM BROMIDE** ( $\text{NaBr}$ )

This salt occurs in the form of white, cubical crystals, or as a white, granular powder, odorless, and having a saline, bitterish taste. It is soluble in both water and alcohol.

Sodium bromide is used as a sedative, anti-epileptic and hypnotic.

**POTASSIUM BROMIDE (KBr)**

Potassium bromide ("bromide of potash") occurs in the form of white, cubical crystals, or as a white, granular powder, without odor, and having a strongly saline taste. It is soluble in water, but not very soluble in alcohol.

It is used like the sodium salt.

**AMMONIUM BROMIDE (NH<sub>4</sub>Br)**

The compound occurs in the form of colorless, transparent crystals, or as a white, crystalline powder. It is odorless, has a pungent, saline taste, and is soluble in both water and alcohol. Upon exposure to the air the salt undergoes slight decomposition, becoming yellowish in color.

The salt is used as a nervous sedative.

**CALCIUM BROMIDE (CaBr<sub>2</sub>)**

A white, granular, odorless, very deliquescent salt, having no odor, but a sharp, saline taste. It is very soluble in water and alcohol.

The salt is used as a sedative like sodium bromide.

**LITHIUM BROMIDE (LiBr)**

Lithium bromide is a white, crystalline powder, without odor and having a sharp, slightly bitter taste. It is very soluble in water and alcohol.

It is used especially in the treatment of epilepsy, headache, and acute and chronic parenchymatic nephritis.

**STRONTIUM BROMIDE (SrBr<sub>2</sub>)**

The salt occurs as transparent, colorless crystals, odorless and having a bitter, saline taste. It is very deliquescent, and soluble in water and alcohol.

The compound is used as a sedative and tonic.

**ZINC BROMIDE (ZnBr<sub>2</sub>)**

Zinc bromide is a white, granular powder, odorless and having a sharp, saline, metallic taste. It is very deliquescent, and is soluble in water and alcohol.

It is astringent as well as sedative.



**"Bromism."**—If the bromides are given internally in too large doses or over too long a period of time, they give rise to poisoning, known as "bromism."

**Test for Bromides.**—When a solution of a bromide is shaken with chlorine water and a little chloroform, bromine is liberated and dissolved out by the chloroform, which settles to the bottom as a red globule.

### IODIDES

These are salts of hydriodic acid.

#### SODIUM IODIDE (NaI)

Sodium iodide occurs as colorless, cubical crystals, or as a white, crystalline powder, having a saline, slightly bitter taste and no odor. It is deliquescent and becomes brown upon standing. It is soluble in water.

#### POTASSIUM IODIDE (KI)

"Iodide of potash" occurs in the form of colorless, transparent or opaque, white, cubical crystals, or as a white, granular powder. It has a pungent, bitter taste and a faint odor. It is very soluble in water, and also in alcohol. Aqueous solutions, upon standing, undergo slight decomposition and become yellow.

#### AMMONIUM IODIDE (NH<sub>4</sub>I)

A white, granular powder, or minute, colorless crystals, having a sharp, saline taste and no odor. Soluble in water and alcohol. It is deliquescent. Upon standing it undergoes decomposition, becoming yellow to yellow-brown.

#### MERCUROUS IODIDE (HgI)

*"Yellow Mercurous Iodide"*      *"Green Iodide of Mercury"*  
*"Protiodide of Mercury"*

This compound occurs as a heavy, bright yellow, amorphous, odorless, tasteless powder. It is insoluble in water and alcohol. Upon exposure to light it changes color, becoming greenish-gray.

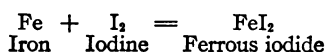
**MERCURIC IODIDE (HgI<sub>2</sub>)**

“ *Red Mercuric Iodide* ”      “ *Biniodide of Mercury* ”

The mercuric iodide occurs as a scarlet-red, amorphous powder. It is odorless, tasteless, practically insoluble in water, but slightly soluble in alcohol. It dissolves in an aqueous solution of potassium iodide.

**FERROUS IODIDE (FeI<sub>2</sub>)**

This salt may be prepared by warming a mixture of iodine and fine iron wire.



The compound is not very stable, therefore sugar is added to the greenish mixture resulting from the combination, to prevent oxidation. The mixture is then very carefully evaporated to dryness and powdered. **Syrup of Ferrous Iodide** (5 per cent. of FeI<sub>2</sub>) and **Pills of Ferrous Iodide** (“*Blanchard's Pills*”): each pill contains 1 grain of FeI<sub>2</sub>) are official.

**ARSENOUS IODIDE (AsI<sub>3</sub>)**

An orange-red, stable, crystalline, inodorous powder. It is soluble, with partial decomposition, in water and alcohol. It is *very toxic* and is given only in very small doses. The official solution of arsenous and mercuric iodides (“*Donovan's Solution*”) contains 1 per cent. of arsenous iodide and 1 per cent. of mercuric iodide.

**BISMUTH OXYIODIDE (BiOI)**

Bismuth oxyiodide, a very fine, crystalline, odorless, tasteless, insoluble powder, is sometimes used as a substitute for iodoform; *i.e.*, as an external antiseptic.

**USES OF THE IODIDES**

The alkali iodides (K, Na, NH<sub>4</sub>) afford a convenient way for administering iodine internally. They are used as antisyphilitics, antirheumatics, etc., promoting the absorption of exudates. The iodides of arsenic and mercury possess valuable tonic properties. Zinc iodide (ZnI<sub>2</sub>) is astringent.

**"Iodism."**—When large doses are given, or when iodides are given over too long a period of time, poisonous symptoms develop, giving rise to the condition known as "iodism."

**Test for Iodides.**—When a solution of an iodide is shaken with some chlorine water and chloroform, the iodine is liberated and dissolved out by the chloroform, which settles to the bottom as a violet globule.

## SULPHO-SALTS

### SULPHITES

These are salts of the dibasic acid, sulphurous acid. **Sodium sulphite** ( $\text{Na}_2\text{SO}_3$ ), **sodium acid (bi-) sulphite** ( $\text{NaHSO}_3$ ), and **calcium sulphite** ( $\text{CaSO}_3$ ) have been employed by manufacturers as food preservatives and bleaching agents.

### SULPHATES

Sulphates are salts of the dibasic acid, sulphuric acid.

#### MAGNESIUM SULPHATE ( $\text{MgSO}_4$ )

*"Epsom Salt"*      *"Bitter Salt"*

Magnesium sulphate occurs natively in deposits and in mineral waters. It comes in the form of small, colorless, odorless, needle-shaped crystals, with a cooling, saline, bitter taste. It is very soluble in water and is efflorescent.

Magnesium sulphate is employed in medicine as a saline purge and refrigerant.

#### SODIUM SULPHATE ( $\text{Na}_2\text{SO}_4$ )

*"Glauber's Salt"*      *"Horse Salt"*

This salt occurs natively in deposits and in mineral waters. It comes in the form of granular crystals or as large, colorless, transparent prisms, having a saline, bitter taste and no odor. It is efflorescent and soluble in water.

Sodium sulphate is a saline purge, but, because of its irritant effect, is little used except in veterinary medicine.

**FERROUS SULPHATE ( $\text{FeSO}_4$ )**

*"Copperas "*      *"Green Vitriol "*

This forms large, pale, bluish-green crystals, without odor and having a saline, styptic taste. Upon exposure to air the crystals effloresce. It is very soluble in water, but insoluble in alcohol. **Exsiccated** and **granular** ferrous sulphate, as well as the crystalline variety, are official.

It is employed in medicine as an astringent, styptic, and tonic.

**COPPER SULPHATE ( $\text{CuSO}_4$ )**

*"Blue Stone "*      *"Blue Vitriol "*

Copper sulphate forms large, deep-blue, transparent crystals, which have a nauseous, metallic, astringent taste and no odor. It slowly effloresces upon exposure to dry air. It is soluble in water and slightly so in alcohol.

It is employed in medicine as an astringent and emetic.

**ALUMINIUM SULPHATE ( $\text{Al}_2(\text{SO}_4)_3$ )**

Aluminium sulphate is a white, crystalline powder, having a sweetish, astringent taste but no odor. It is soluble in water but insoluble in alcohol.

In medicine it is useful as an astringent and antiseptic.

**POTASSIUM ALUMINIUM SULPHATE ( $\text{KAl}(\text{SO}_4)_2$ )**

*"Alum "*

This double salt of sulphuric acid occurs in the form of large, colorless crystals or as a white, crystalline powder, having a strongly astringent, sweetish taste, but no odor. It is soluble in water and insoluble in alcohol. **Exsiccated Alum** (*"Burnt"* or *"Dried Alum"*) is official.

It is employed as an astringent, styptic, and cauterant.

**ZINC SULPHATE ( $\text{ZnSO}_4$ )**

*"White Vitriol "*

Zinc sulphate occurs as white or colorless, transparent crystals, without odor, and having an astringent, metallic taste. It is efflorescent and soluble in water, but insoluble in alcohol.

The salt is a pronounced astringent and emetic, as well as an antiseptic and escharotic. Because of its close resemblance to magnesium sulphate it has been taken in mistake for the latter compound, poisoning resulting. Alkali carbonates (diluted), tannic acid, albumen, and demulcents may be given as antidotes.

#### CALCIUM SULPHATE ( $\text{CaSO}_4$ )

##### *"Gypsum"*

This salt occurs natively. It is a white, crystalline powder, without odor or taste. It is slightly soluble in water.

The **exsiccated** variety, commonly known as "*plaster of Paris*," is prepared by applying heat to the native salt. It occurs as a fine, white, odorless, tasteless powder. When mixed with one-half its weight of water it forms a smooth, cohesive paste which hardens rapidly. Because of this property the compound is used for casts and splints by surgeons and for moulds by dentists. It is also used for giving a hard finish to walls and as a filling for writing-paper.

**Test for Sulphates.**—A solution of barium chloride ( $\text{BaCl}_2$ ) added to a sulphate solution produces a white precipitate of barium sulphate ( $\text{BaSO}_4$ ).

#### SULPHIDES

##### CALCIUM SULPHIDE ( $\text{CaS}$ )

##### *"Sulphurated Lime"*

"Sulphurated lime" is a mixture containing about 60 per cent. of calcium sulphide, and occurs as a pale, gray powder having a faint odor of hydrogen sulphide and a nauseous, alkaline taste. It is sparingly soluble in water and insoluble in alcohol.

It is employed as an escharotic for the removal of superfluous hair, and in the treatment of boils.

##### CARBON DISULPHIDE ( $\text{CS}_2$ )

This compound is a colorless, volatile liquid with a fetid odor. It is miscible with alcohol, ether, chloroform, and oils, but is immiscible with water. The compound is *very inflammable* and acts as a depressant poison when inhaled.

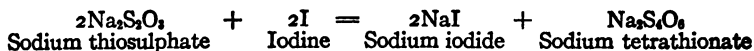
It is employed as a solvent for rubber, oils, sulphur, iodine, and phosphorus, and as an efficient insecticide.

**THIOSULPHATES****SODIUM THIOSULPHATE** ( $\text{Na}_2\text{S}_2\text{O}_3$ )

*"Sodium Hyposulphite"*      *"Hypo"*

It occurs as large, colorless crystals, odorless, and with a cooling, saline, bitter taste. It is soluble in water.

It is an antiseptic and germicide, and is used in the preparation of the solution known as *"Colorless Tincture of Iodine."* In the preparation of the latter it should be remembered that all of the iodine is converted to sodium iodide, according to the following equation:



It is also used in photography, paper manufacture, in metallurgy, and as a disinfectant for drinking water.

**NITRO-SALTS****NITRATES****SODIUM NITRATE** ( $\text{NaNO}_3$ )

*"Chili Saltpetre"*

Sodium nitrate is found in deposits in the rainless portions of Chili. It occurs as colorless, transparent crystals, without odor, and having a cooling, saline, bitterish taste. It is soluble in water and slightly so in alcohol.

The salt is rarely employed in medicine.

**POTASSIUM NITRATE** ( $\text{KNO}_3$ )

*"Saltpetre"*

This salt occurs as colorless, transparent crystals, or as a white, crystalline powder, without odor, and having a cooling, saline, pungent taste. It is soluble in water and sparingly soluble in alcohol.

The salt is rarely used internally in medicine. However, it is employed in the manufacture of potassium nitrate paper, com-

pound powders, and cigarettes which are intended to be used by burning and inhaling the vapors to relieve asthmatic attacks. It is also used in the manufacture of gunpowder and fireworks.

#### SILVER NITRATE ( $\text{AgNO}_3$ )

Silver nitrate occurs as colorless, transparent crystals, without odor, and having a bitter, caustic, metallic taste. It is very soluble in water. Upon exposure to light it becomes dark in color, and therefore should be kept in blue and amber bottles.

**Moulded Silver Nitrate**, or "*Lunar Caustic*," is prepared by heating together silver nitrate and hydrochloric acid, and pouring the fused mass into moulds. It occurs in the form of white, opaque pencils.

**Mitigated Silver Nitrate**, or "*Mitigated Caustic*," is prepared by fusing a mixture of silver nitrate and potassium nitrate and pouring the fused mass into moulds. It also occurs in the form of pencils or cones.

Silver nitrate is employed as an antiseptic, irritant, stimulant, and escharotic. Internally its use is limited because of its caustic effect. If given internally over a long period of time, it causes "*argyria*"; i.e., deposits of the metal in the connective tissue of the various organs.

#### BISMUTH SUBNITRATE ( $\text{BiONO}_3$ )

This is a heavy, white, odorless, tasteless, insoluble powder. It is employed in medicine as an astringent and antiseptic.

#### MERCURIC NITRATE ( $\text{Hg}(\text{NO}_3)_2$ )

Mercuric nitrate, a white, deliquescent powder, is used in the form of **Solution of Mercuric Nitrate** (50 per cent.) and **Ointment of Mercuric Nitrate**, or "*Citrine Ointment*." It is antiseptic and antisyphilitic.

**Test for Nitrates.**—A few drops of a solution of brucine in sulphuric acid added to a drop of a nitrate solution produce a deep red color at the point of contact. The color fades to yellow,

## PHOSPHO-SALTS

### PHOSPHATES (Ortho)

#### SODIUM PHOSPHATE ( $\text{Na}_2\text{HPO}_4$ )

*"Phosphate of Soda"*

Large, colorless, odorless crystals, or a white, granular powder, having a cooling, saline taste. It effloresces in air, and is soluble in water. **Exsiccated Sodium Phosphate** and **Effervescent Sodium Phosphate** are official.

The salt is employed as a saline cathartic and laxative.

#### CALCIUM PHOSPHATE ( $\text{Ca}_3(\text{PO}_4)_2$ )

Calcium phosphate is found natively and as a constituent of bones. The **precipitated** variety is official, and occurs as a white, amorphous, odorless, tasteless, almost insoluble powder.

It is employed in cheap baking powders and in fertilizers. In medicine it is used as an antacid, to supply bone salt, and as a dusting powder.

#### FERRIC PHOSPHATE ( $\text{FePO}_4$ )

This salt is official under the title **"Soluble Ferric Phosphate."** It occurs as thin, bright-green, transparent scales, having an acidulous, slightly saline taste and no odor. Soluble in water and insoluble in alcohol.

It is used in medicine as a tonic.

## PYROPHOSPHATES

#### FERRIC PYROPHOSPHATE ( $\text{Fe}_2(\text{P}_2\text{O}_7)_3$ )

This *scale* salt is official as **"Soluble Ferric Pyrophosphate."** It occurs as apple-green, transparent scales, odorless, and having an acidulous, saline taste. It is soluble in water, but insoluble in alcohol. Upon exposure to light the salt is discolored.

It is used as a tonic.



**SODIUM PYROPHOSPHATE ( $\text{Na}_2\text{H}_2\text{P}_2\text{O}_7$ )**

This salt occurs as colorless, transparent crystals, or as a white, crystalline powder, odorless and having a cooling, saline, alkaline taste. It is soluble in water.

This salt is used for the same purposes as is sodium phosphate.

**HYPOPHOSPHITES**

**Sodium Hypophosphite**  
( $\text{NaPH}_2\text{O}_2$ )

**Potassium Hypophosphite**  
( $\text{KPH}_2\text{O}_2$ )

**Ferric Hypophosphite**  
( $\text{Fe}(\text{PH}_2\text{O}_2)_3$ )

**Manganese Hypophosphite**  
( $\text{Mn}(\text{PH}_2\text{O}_2)_2$ )

**Calcium Hypophosphite** ( $\text{Ca}(\text{PH}_2\text{O}_2)_2$ )

The above salts are constituents of the official **Syrup of Hypophosphites** and **Compound Syrup of Hypophosphites**, which are used in wasting diseases. Since the salts are active reducing agents, they should not be rubbed with oxidizing agents for fear of violent explosion.

**CARBONATES****SODIUM CARBONATE ( $\text{Na}_2\text{CO}_3$ )**

*" Sal Soda "      " Washing Soda "*

Sodium carbonate is a white, crystalline, odorless powder with a strongly alkaline taste and reaction. It is soluble in water, and is efflorescent.

In large doses it is a caustic poison. It is rarely used internally. One per cent. solutions have been used as gargles, injections, nasal douches, and mouth-washes. It is also used in photography, in the manufacture of soaps, washing powders, glass, paper, dyes, for washing wool, etc.

**POTASSIUM CARBONATE ( $\text{K}_2\text{CO}_3$ )**

*" Potash "      " Salts of Tartar "      " Pearl Ash "*

The salt is a white, granular, deliquescent, odorless powder with a strongly alkaline taste. It is soluble in water.

It is a caustic poison like the sodium salt, and, if administered internally, should be well diluted.

It is used like the sodium salt.

**AMMONIUM CARBONATE** ( $\text{NH}_4\text{HCO}_3 \cdot \text{NH}_4\text{NH}_2\text{CO}_2$ )*"Sal Volatile"*

From the formula given above it will be seen that the official ammonium carbonate is a mixture of ammonium bicarbonate and ammonium carbamate. It is a white, hard, translucent, striated mass, with a strong odor of ammonia and a sharp, saline taste. Upon exposure to the air it becomes opaque. It is soluble in water.

Ammonium carbonate is a stimulant, expectorant, and irritant.

**FERROUS CARBONATE** ( $\text{FeCO}_3$ )

There are several official preparations that contain this salt. They are **Saccharated Ferrous Carbonate**, a greenish-brown powder containing, in addition to the iron salt, some sugar to prevent oxidation; **Mass of Ferrous Carbonate**, more commonly known as "*Vallet's Mass*," a soft, greenish mixture of pillular consistence; **Compound Iron Mixture** ("*Griffith's Mixture*"), an opaque, greenish liquid with a sweetish, ferruginous taste; **Pills of Ferrous Carbonate**, known as "*Blaud's*" or "*Iron Pills*," each pill containing about 1 grain of the salt.

The preparations are used chiefly in the treatment of anæmia.

**MAGNESIUM CARBONATE** ( $(\text{MgCO}_3)_4 \cdot \text{Mg}(\text{OH})_2$ )*"Magnesia Alba"*

Magnesium carbonate is a white, loose, bulky powder without odor, but with an earthy taste. It is insoluble in water.

In medicine it is used as an antacid, laxative, and purge. It is also employed in the manufacture of **Effervescing Solution of Magnesium Citrate**.

**LITHIUM CARBONATE** ( $\text{Li}_2\text{CO}_3$ )

A light, white, odorless powder with an alkaline taste. It is soluble in water and insoluble in alcohol.

It has been used as a uric acid solvent, also in the manufacture of mineral waters.

**CALCIUM CARBONATE ( $\text{CaCO}_3$ )**

Calcium carbonate occurs natively as *limestone*, *marble*, and *chalk*. **Precipitated Calcium Carbonate** is official. It is a fine white powder without odor or taste and slightly soluble in water. It is used in medicine as an antacid, mild astringent, and dusting powder. It is also used for the preparation of carbon dioxide gas ( $\text{CO}_2$ ).

Another official variety of the salt is **Prepared Chalk**, an amorphous, heavy, white, very fine powder, often moulded into cones, having no odor or taste, and being almost insoluble in water. In addition to its use as an antacid, mild astringent, and dusting powder, it is employed as an ingredient of tooth-powders because of its non-crystalline structure.

"*Whiting*" and "*Paris white*" are commercial varieties of prepared chalk, but not as pure and white as the medicinal compound. They are used in polishing powders, building, etc.

**ZINC CARBONATE ( $\text{ZnCO}_3$ )**

**Precipitated Zinc Carbonate**, which is really basic in structure, —*i.e.*,  $2\text{ZnCO}_3 + 3\text{Zn}(\text{OH})_2$ ,—is official, and occurs as a white, impalpable, odorless, tasteless powder. It is insoluble in water and alcohol. "**Calamine**" is an impure variety and is employed as an astringent, absorbent, and dusting powder.

**BICARBONATES****SODIUM BICARBONATE ( $\text{NaHCO}_3$ )**

"*Baking Soda*"

"*Soda*"

This salt occurs as a white, opaque powder, odorless, and having a cooling, mildly alkaline taste. It is soluble in water. If its solutions are heated or vigorously shaken, the compound is converted to the neutral salt,  $\text{Na}_2\text{CO}_3$ .

It is used as an antacid, in effervescing drinks, mixtures and salts, and as an ingredient of baking powders. It also possesses mild antiseptic and antipyretic properties.

**POTASSIUM BICARBONATE ( $\text{KHCO}_3$ )**

Potassium bicarbonate occurs as colorless, transparent crystals or as a white, granular powder. It is odorless and has a saline, slightly alkaline taste. It is soluble in water.

In medicine the salt is employed as an antacid, an alkaline diuretic, and in making effervescing drinks.

**Test for Carbonates and Bicarbonates.**—These salts effervesce with acids, giving off carbon dioxide gas ( $\text{CO}_2$ ), which, when passed into lime water ( $\text{Ca}(\text{OH})_2$ ), produces a white turbidity.

**BORATES****SODIUM BORATE ( $\text{Na}_2\text{B}_4\text{O}_7$ )**

“ *Borax* ”

“ *Sodium Tetraborate* ”

Borax occurs in nature in large quantities. It is a colorless, odorless, crystalline solid, or a white powder, with a sweetish, alkaline taste. It dissolves in water.

The salt is used as a feeble antiseptic. It is also employed for soldering, welding, in the manufacture of soaps, as a food preservative, and in the manufacture of certain glass and enamels.

**Test for Borax.**—A mixture of borax, sulphuric acid and alcohol, when ignited, gives a green flame.

**ARSENITES AND ARSENATES**

Both classes of salts are very poisonous, and are given internally in very small doses.

**Potassium arsenite** ( $\text{KAsO}_2$ —*Metarsenite*) is found in the official Solution of Potassium Arsenite, commonly known as “ *Fowler's Solution*,” which should contain the arsenical compound corresponding in amount to 1 per cent. of arsenic trioxide.

**Sodium arsenate** ( $\text{NaHAsO}_4$ ) is the most important salt. It occurs as colorless crystals, odorless, but having a mild alkaline taste. It is soluble in water. The **exsiccated** variety is official, as well as **Solution of Sodium Arsenate** (1 per cent.).

“ **Paris green**,” a green pigment and insecticide, is copper aceto-arsenite.

"**Scheele's green**," another common green pigment, is copper arsenite.

Arsenical compounds are usually irritant, caustic, and tonic. They are also employed in embalming fluids and in paints.

**Test for Arsenic.**—Hydrogen sulphide ( $H_2S$ ) gives a yellow precipitate with solutions of arsenical compounds.

## PERMANGANATES

### POTASSIUM PERMANGANATE ( $KMnO_4$ )

This salt occurs as dark purple, lustrous, odorless prisms with a sweetish, astringent taste. It is soluble in water.

It is a powerful oxidizing agent, and is used as a disinfectant, deodorant, and antidote in alkaloidal poisoning.

**Test.**—Solutions of permanganates are decolorized by oxalic acid.

## CYANIDES

### POTASSIUM CYANIDE ( $KCN$ )

*" Prussiate of Potash "*

Potassium cyanide is a white, opaque, amorphous solid, or a white, granular powder, with no odor unless it is moist, and having a sharp, bitter, saline taste. It is very soluble in water, and is *extremely* poisonous.

It is used in medicine in minute doses as a sedative. It is also employed in metallurgy and photography.

Hydrogen peroxide solution, chlorine water, solution of chlorinated soda, ammonia, ferrous sulphate, emetics, artificial respiration, freshly-precipitated ferric hydroxide with sodium carbonate are used as antidotes in poisoning by this salt.

# OXIDES

## CHAPTER XI

### NON-METALLIC OXIDES

#### OXIDES OF HYDROGEN

Hydrogen and oxygen combine in two proportions:

**Hydrogen monoxide** or water ( $\text{H}_2\text{O}$ )

**Hydrogen dioxide** ( $\text{H}_2\text{O}_2$ )

#### WATER ( $\text{H}_2\text{O}$ )

Water is one of the most abundant compounds in nature. It constitutes about 68 per cent. of the human body, from 75 to 95 per cent. of plant and animal life, and is found as "water of crystallization" in most minerals. It occurs naturally in the three physical states: *solid* below  $0^\circ \text{C.}$ , *liquid* between  $0^\circ$  and  $100^\circ \text{C.}$ , and *gaseous* above  $100^\circ \text{C.}$

**Experiment 16.**—Heat a piece of meat in a *dry* test-tube. Note the escape of steam from the mouth of the tube and the condensation of the vapor on the cooler portions of the tube. Repeat the same with a piece of "dry" wood.

The simplest method for preparing water is to burn a jet of hydrogen under a dry, cool bell-jar. The inner surface of the bell-jar will become coated with a film of moisture.

Pure water is a colorless, odorless, tasteless, transparent liquid. In deep layers it has a bluish-green color. The greatest density of water is at  $4^\circ \text{C.}$  Above and below this temperature it expands. It is the most common and useful solvent.

When water contains much of the salts of calcium and magnesium it does not readily form a lather with soaps, because these salts form insoluble compounds with the soap, and is called "**hard.**" The "**hardness**" of water may be of two kinds; *i.e.*:

**Temporary Hardness.**—Due to calcium and magnesium bicarbonates. This may be overcome by boiling, the bicarbonates decomposing and forming the insoluble neutral carbonates.

**Permanent Hardness.**—Due to the presence of calcium and magnesium sulphates. This cannot be overcome by boiling, but the addition of sodium bicarbonate or carbonate will cause the precipitation of insoluble carbonates of the two metals.

In assuming the crystalline form many chemical compounds unite with a certain amount of water, which is known as "**water of crystallization.**" The crystalline form and, in many cases, the color are dependent upon the presence of the water.

**Experiment 17.**—Apply moderate heat to some crystals of copper sulphate contained in a dry test-tube. Note the condensation of the water on the cool parts of the tube, the passage of steam from the mouth, and the crumbling of the blue crystals to a whitish powder. The heat drove off the water of crystallization.

**Efflorescence.**—Many crystalline salts, when exposed to the atmosphere, gradually lose their water of crystallization, forming a powder.

**Experiment 18.**—Allow some crystals of ferrous sulphate to stand in a dry, uncovered dish over night. Note the loss of color and crystalline form, a powder resulting.

**Hygroscopic compounds** are such as absorb moisture from the atmosphere.

**Experiment 19.**—Expose some "Argyrol" (an organic compound of silver) to the air for a short time. Note the moist condition of the compound even after but a few minutes of exposure.

**Deliquescence.**—This term is applied to those compounds which absorb sufficient moisture from the air to dissolve them.

**Experiment 20.**—Expose some pieces of fused calcium chloride to the air over night. Note the resulting solution.

The purest form of natural water is **rain water**. Any water that is pure enough, from the chemical and sanitary standpoints, for domestic purposes is known as **potable water**. **Distilled water** is made by distilling 1000 parts of natural water, discarding the first and last 100 parts. The first 100 parts of distillate contain the volatile impurities, while the last 100 contain the non-volatile ones. When water contains sufficient mineral or gaseous

matter in solution to render it of some value for medicinal purposes it is called a **mineral water**. **Carbonated waters** are those which contain considerable carbon dioxide gas in solution. **Sulphur waters** contain hydrogen sulphide in solution. **Alkaline waters** are those which contain considerable quantities of sodium bicarbonate and sodium and magnesium sulphate in solution. **Lithia waters** contain very small quantities of lithium chloride or carbonate. **Saline waters** contain large amounts of magnesium and sodium sulphates and sodium chloride. **Chalybeate waters** contain iron compounds. **Sea-water** averages from 3 to 4 per cent. of inorganic salts, sodium chloride being the largest constituent, and the remainder consisting chiefly of magnesium chloride and sulphate and calcium sulphate.

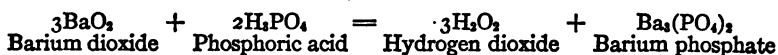
Water is more needed by the human system than solid food. It serves to assist in the processes of solution, secretion, excretion, circulation, and the regulation of heat by perspiration and evaporation. About six pints of water should be taken by an adult daily.

#### HYDROGEN DIOXIDE ( $H_2O_2$ )

" *Peroxide* "

" *Peroxide of Hydrogen* "

Hydrogen dioxide is a colorless, syrupy liquid with a tingling, metallic taste. It is very soluble in water and is usually prepared by the action of phosphoric acid on barium dioxide.



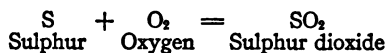
The official **Solution of Hydrogen Dioxide** is an aqueous solution containing about 3 per cent. of the compound. It readily decomposes upon exposure to sunlight with the formation of water and oxygen, and should, therefore, be kept in amber bottles in a cool place. Acetanilide is usually added to preserve the solution.

The solution is employed for bleaching teeth, hair, and wool, for cleansing, and as an antiseptic and disinfectant. It is also used in hydrocyanic ("Prussic") acid poisoning because of its oxidizing powers. It effervesces with pus, blood, saliva, and other organic substances.



**SULPHUR DIOXIDE (SO<sub>2</sub>)**

When sulphur is burned in the air it forms sulphur dioxide.



It is found as a component of volcanic vapors, and in small quantities in the atmosphere of cities. It is a colorless gas with a suffocating odor, and is soluble in water.

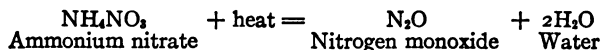
The gas is extensively used in bleaching, disinfecting, and the manufacture of sulphuric acid and sulphites.

**NITROGEN MONOXIDE (N<sub>2</sub>O)**

*" Nitrous Oxide "*

*" Laughing Gas "*

This compound may be prepared by carefully heating ammonium nitrate (NH<sub>4</sub>NO<sub>3</sub>). Decomposition takes place according to the following equation:



It is a colorless gas with a faint, peculiar odor and a sweetish taste. It can be liquefied, and is usually kept, for convenience, in iron cylinders under pressure. It has received the name " laughing gas " because of the exhilarating effects it first produces when inhaled.

It is used as an anæsthetic, but must be mixed with air or oxygen.

**CARBON MONOXIDE (CO)**

This compound is formed when coal is burned with an insufficient supply of air. It is a colorless, almost odorless gas, and burns with a blue flame, forming carbon dioxide (CO<sub>2</sub>).

When inhaled, carbon monoxide acts as a narcotic poison, giving rise to dizziness, headache, nausea, convulsions, and death. Five-tenths per cent. is fatal to animals. Death is not produced by simple suffocation, but is due to the union of the gas with the hæmoglobin of the blood, which prevents the absorption of oxygen.

Carbon monoxide is the essential poison in illuminating gas. "Choke-damp," in mines, is a mixture of carbon monoxide and carbon dioxide.

### CARBON DIOXIDE (CO<sub>2</sub>)

#### *"Carbonic Acid Gas"*

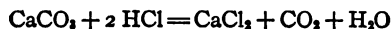
Carbon dioxide is found in small quantities in the atmosphere, especially in the neighborhood of cities. It is also a product of fermentation and combustion of organic matter.

It is a colorless, odorless gas with a weak acid taste, and is soluble in one part of water. With increase of pressure the solubility uniformly increases. Thus, under a pressure of 5 atmospheres, 5 volumes of the gas are dissolved by 1 volume of water. This solution is known as "soda water." The gas does not support combustion.

Carbon dioxide is not a poison in itself, but acts as one through the mechanical exclusion of oxygen when inhaled, suffocation taking place. Ventilated rooms contain from 5 to 6 parts of carbon dioxide per 10,000. Expired air contains from 4 to 5 per cent. of the gas. More than 7 parts per 10,000 are oppressive and injurious. It is estimated that at least 2000 cubic feet of fresh air should be furnished an adult every hour. An ordinary lamp, in burning, sets free as much carbon dioxide as an adult; a gas-jet, two to four times as much.

Internally the gas is an agreeable stimulant and is used in beverages. It is used in large quantities as "chemical fire-extinguishers." Plants make use of large quantities in their growth.

**Experiment 21.**—Place several pieces of limestone (CaCO<sub>3</sub>) in a flask fitted with a two-holed rubber stopper carrying a funnel-tube and a bent glass tube leading to a vessel of water. Fill a wide-mouth bottle with water and invert it in the vessel of water over the tube leading from the flask. Add hydrochloric acid gradually through the funnel-tube. Carbon dioxide will be evolved and collected in the bottle. Remove the bottle and insert a lighted taper into it. What happens? Allow the gas from the tube to bubble through some clear lime water and note the resulting milky turbidity, due to the formation of calcium carbonate, which is almost insoluble.



## CHAPTER XII

### METALLIC OXIDES

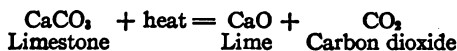
#### CALCIUM OXIDE (CaO)

" *Lime* "

" *Quicklime* "

" *Calx* "

**LIME** or calcium oxide may be readily prepared by heating limestone or marble ( $\text{CaCO}_3$ ).



It occurs in white, hard, amorphous masses, without odor, but having a sharp, caustic taste. It is slightly soluble in water, forming "slaked lime" ( $\text{Ca(OH)}_2$ ).

It is used in the manufacture of mortars and cements. In medicine the solution "lime water" is employed.

#### LEAD OXIDE (PbO)

" *Lead Monoxide* "

" *Litharge* "

This occurs as a heavy, yellowish or reddish-yellow powder, without odor or taste. It is almost insoluble in water.

Medicinally, it is employed only in the manufacture of **Lead Plaster**, **Goulard's Extract** (solution of lead subacetate), and **Lead Water** (diluted solution of lead subacetate). It is also used in the manufacture of flint glass and porcelain-ware.

#### MAGNESIUM OXIDE (MgO)

" *Calcined Magnesia* "

" *Magnesia* "

Two varieties of this compound are official: **Light Magnesium Oxide** and **Heavy Magnesium Oxide**.

The light variety is a light, bulky, white powder, without odor, but with a saline taste. It is almost insoluble in water. When mixed with water it forms a white, gelatinous mass, known as "**Milk of Magnesia**."

The heavy variety is a denser and finer powder, but in most other characteristics resembles the light variety.

In medicine the compound is used as an antacid and purge. It is also added to milk to increase the alkalinity and to act as a laxative.

#### MERCURIC OXIDE ( $\text{HgO}$ )

There are two varieties of mercuric oxide: **Yellow** and **Red**.

**Yellow Mercuric Oxide** occurs as a light yellow, amorphous, impalpable, odorless powder, having a metallic taste. It is almost insoluble in water, and darkens upon exposure to light.

**Red Mercuric Oxide** occurs as a heavy, orange-red, crystalline powder, without odor, but having a metallic taste. It is almost insoluble in water.

Both varieties are used as antiseptics and antisypilitics. The red oxide is more irritating to the skin than the yellow. In the preparation of ointments for the eyes the yellow variety should be employed because it is amorphous.

#### ZINC OXIDE ( $\text{ZnO}$ )

Zinc oxide is a white, soft, very fine, amorphous, inodorous, tasteless powder, insoluble in water.

It is used in the manufacture of paints, cosmetics, ointments, glass, etc. In medicine it is employed as a mild astringent, absorbent dusting powder, and antiseptic in the form of **Ointment of Zinc Oxide** ("*Zinc Salve*") in "weeping" diseases.

#### ARSENIC TRIOXIDE ( $\text{As}_2\text{O}_3$ )

"*Arsenous Oxide*"      "*White Arsenic*"      "*Arsenic*"

This oxide occurs as a heavy, odorless, tasteless solid, either as a white, opaque powder or an amorphous, semi-transparent, colorless, glassy mass. It is soluble with difficulty in water.

The compound is a very active poison. Beginning with very small doses, the system establishes a toleration for large amounts. It is used in medicine as a caustic, tonic, and in certain skin diseases. It is also employed in embalming, taxidermy, in the manufacture of green pigments, and as an insecticide. In dentistry it is employed as a devitalizing agent for "killing the nerves" of teeth.

**Solution of Arsenous Acid** is a 1 per cent. preparation.



**PART III**  
**ORGANIC CHEMISTRY**



## CHAPTER XIII

### THE COMPOUNDS OF CARBON

THE term *organic* was originally applied to compounds derived directly or indirectly from living plants or animals; all others were termed *inorganic*. In 1828 this assumption was broken down by Wöhler, who manufactured **urea**, a typical secretion of animal organisms, in his laboratory. The number of plant and animal secretions and principles that have been manufactured in the laboratory is so large that we no longer believe that the influence of the supposed "vital force" is essential for their formation. Therefore the division of chemistry into "*inorganic*" and "*organic*," which is still maintained in most chemical text-books, is mainly a matter of convenience.

Organic compounds generally contain but a small number of different elements. These are **carbon**, hydrogen, oxygen, nitrogen, and sometimes sulphur, phosphorus, and iron. All contain **carbon**, therefore organic chemistry is sometimes called the *Chemistry of the Compounds of Carbon*. Some organic compounds are solid, some liquid, and others gaseous. They differ widely in their properties. The combustible property of carbon and hydrogen is transferred to all organic compounds, every one of which will burn when heated sufficiently in air.

**Test for Carbon.**—Carbon may be detected in many organic compounds by heating on a platinum foil or in a porcelain dish. Heat some sugar in a dish over the open flame until it chars. Continue heating strongly, and it will burn away completely unless some non-volatile, inorganic compound is present as an impurity.

**Test for Hydrogen.**—Heat the suspected organic compound with oxide of copper in a dry test-tube. If hydrogen is present, **water** will condense on the upper, cooler parts of the tube.

It is difficult to show by qualitative tests the presence of **oxygen** in an organic compound.

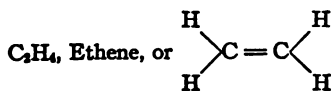
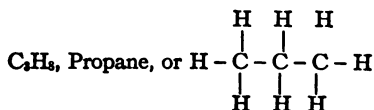
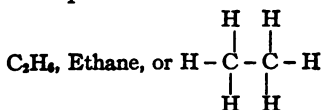


**Test for Nitrogen.**—Heat the substance with soda-lime (a mixture of sodium hydroxide and calcium oxide) in a test-tube. If nitrogen is present, ammonia gas will be liberated. The ammonia may be easily recognized by its characteristic odor and reaction with hydrochloric acid gas.

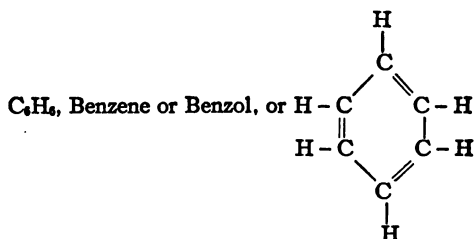
**Test for Sulphur.**—Ignite the substance with metallic sodium. If sulphur is present, sodium sulphide ( $\text{Na}_2\text{S}$ ) is formed, which may be dissolved out by treating the mixture with water. Now add sodium nitro-prusside. A purple coloration develops.


**Test for Phosphorus.**—Oxidize the substance by heating with nitric acid. If phosphorus is present, phosphoric acid will be formed, which yields a yellow precipitate with ammonium molybdate ( $(\text{NH}_4)_2\text{MoO}_4$ ).

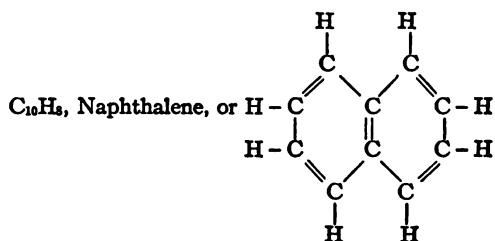
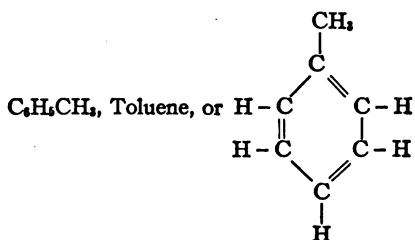
In studying and writing the formulæ for organic compounds the student will be materially assisted by writing the structural or graphic formulæ, which are intended to show the theoretical arrangements of the atoms within the molecule. In organic compounds where a series of carbon atoms are held together by one or more affinities the expression "*Chain*" or "*Open-chain Series*" is used to designate such theoretical arrangement. For example:



Where the carbon atoms of the molecule are united alternately by single and double linkage we have what is known as the "*Closed Chain*" compounds or series. For example:



sometimes simply written , the carbon and hydrogen being understood, and the figure known as a "*Benzol Ring*."



## CHAPTER XIV

### HYDROCARBONS

THE hydrocarbons constitute a class of organic substances which are simply compounds of carbon with hydrogen. They are mostly vegetable products, being built up by plants from water and carbon dioxide from the air. Most of them are colorless, insoluble in water, soluble in ether and alcohol, neutral, stable, and volatile.

They are usually divided into the following series:

Prefixes.	Series I. <i>Paraffins</i> ( $C_nH_{2n+2}$ )	Series II. <i>Olefins</i> ( $C_nH_{2n}$ )	Series III. <i>Acetylenes</i> ( $C_nH_{2n-2}$ )	Series IV. <i>Terpenes</i> ( $C_nH_{2n-4}$ )	Series V. <i>Benzenes</i> ( $C_nH_{2n-6}$ )
Meth-	-ane : $CH_4$				
Eth-	-ane : $C_2H_6$	-ene or -ylene : $C_2H_4$	-ine : $C_2H_2$		
Prop-	-ane : $C_3H_8$	-ene or -ylene : $C_3H_6$	-ine : $C_3H_4$	-one : $C_3H_2$	
But-	-ane : $C_4H_{10}$	-ene or -ylene : $C_4H_8$	-ine : $C_4H_6$	-one : $C_4H_4$	-une : $C_4H_2$
Pent-	-ane : $C_5H_{12}$	-ene or -ylene : $C_5H_{10}$	-ine : $C_5H_8$	-one : $C_5H_6$	-une : $C_5H_4$
Hex-	-ane : $C_6H_{14}$	-ene or -ylene : $C_6H_{12}$	-ine : $C_6H_{10}$	-one : $C_6H_8$	-une : $C_6H_6$
	to $C_{40}H_{82}$				

In the above table the prefixes indicate the number of atoms of carbon in the molecule; thus, *Meth*, one atom of carbon; *Eth*, two; *Prop*, three, etc. The suffixes indicate the series, and are in the order of the vowels of the alphabet; *i.e.*, *a*, *e*, *i*, *o*, *u*. The member of a series is two hydrogen atoms less than the corresponding member of the preceding series, as is indicated by the general formula under the name of each series. The compounds that will be studied in this text are principally members of the first and fifth series.

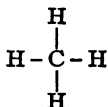
## THE PARAFFINS OR FATTY SERIES

The first four members of this series—Methane ( $\text{CH}_4$ ), Ethane ( $\text{C}_2\text{H}_6$ ), Propane ( $\text{C}_3\text{H}_8$ ), Butane ( $\text{C}_4\text{H}_{10}$ )—are gases; the next twelve members are oily liquids; the rest are fatty or waxy solids.

### METHANE ( $\text{CH}_4$ )

"Fire-damp"

"Marsh-gas"



This is a colorless, tasteless, odorless gas formed by the decomposition of vegetable matter under water. Natural gas contains from 90 to 95 per cent., and coal gas, 30 to 40 per cent. It is a combustible material which is found in mines and may give rise to explosion when ignited.

Ethane, butane, and propane are also found in natural gas.

### PETROLEUM

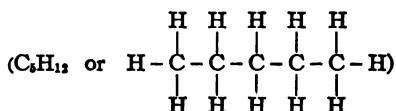
Petroleum is a natural mixture of paraffins up to  $\text{C}_{20}\text{H}_{42}$ . *Crude petroleum* is a thick, brown or yellow liquid obtained by boring wells. The following important products are obtained from petroleum: (a) benzin, (b) gasolene, (c) naphtha, (d) kerosene, (e) paraffin, (f) petrolatum. The foregoing substances have different boiling- and melting-points, and may, therefore, be separated by fractional distillation and purified by redistillation.

### BENZIN

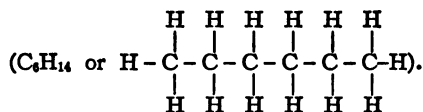
"Benzolin"

"Petroleum Ether"

This is a mixture of pentane



and hexane



It is a colorless liquid, having an ethereal odor and a specific gravity of 0.66. It is a good solvent for oils, fats, resins, and rubber.

### NAPHTHA

*"Safety Oil"*

There are three forms of naphtha, known as "A," "B," and "C." These have different boiling-points. Naphtha is a good solvent for oils, fats, resins, and rubber.

### GASOLENE

This is a very volatile, colorless, and highly inflammable liquid. It is used for gasolene engines, stoves, automobiles, etc., and as a solvent.

### KEROSENE

*"Coal-oil"*

Kerosene is a colorless, volatile, highly inflammable, fluorescent liquid. Its chief uses are for fuel and lighting purposes.

### PETROLATUM

*"Petroleum Jelly" "Cosmoline" "Vaseline"*

Vaseline is chiefly a mixture of hydrocarbons of the paraffin series, obtained by distilling off the more volatile portions of natural petroleum, and purifying and decolorizing by passing through bone-black.

It is a semi-solid mass, varying in color from yellowish to light amber, without odor or taste, insoluble in water, very slightly soluble in alcohol, easily soluble in ether, chloroform, and carbon disulphide. It melts between 45° and 48° C.

It is soothing and protective to the skin and mucous membrane, but is not absorbed. Its chief use is as an ointment base.

**White vaseline** is similar in properties, action, and uses to vaseline, excepting color.

**Liquid petrolatum** ("liquid alboline," "liquid vaseline," or "glycoline") is a colorless or slightly yellowish, oily liquid, without odor and taste. It is insoluble in water, soluble in ether, chloroform, and carbon disulphide. It is used as a protective and soothing agent for mucous membranes, and also serves as a vehicle for volatile oils, camphor, menthol, etc., intended for use by atomization.

#### **PARAFFIN**

##### *" Paraffin Wax "*

This is the residue left after distilling off the above products from petroleum. It is a white, waxy, odorless, tasteless solid having a specific gravity of about 0.9. It is insoluble in water and alcohol, readily soluble in ether, petroleum benzin, carbon disulphide, volatile oils, and warm fixed oils.

In medicine it is used simply to raise the melting-points of ointments and cerates.

#### **THE OLEFINS AND ACETYLENES**

These two series are comparatively unimportant so far as the purposes of this text are concerned.

#### **THE TERPENES**

The most important members of this series are volatile oils, camphor, menthol, thymol, eucalyptol, rubber, gutta-percha, and resins.

#### **VOLATILE OILS**

Volatile oils are liquid preparations usually obtained from flowers, fruits, seed, barks, and leaves by distillation. When subjected to low temperatures many of them separate into two layers; the top layer being known as "eleopten," and the lower layer, "stearopten." Usually they are readily soluble in alcohol, ether, chloroform, and carbon disulphide, but very sparingly so in water.

#### **OIL OF TURPENTINE**

##### *" Spirit of Turpentine "*

This is a volatile oil obtained by distilling the juice of the pine. It is a thin, colorless liquid, with a characteristic taste and odor. It has a specific gravity of about 0.87 and is soluble in water.

The compound is a good solvent for resins, paints, sulphur, and phosphorus. It is used externally in medicine as an irritant, but *should not be used internally*.

**Rectified oil of turpentine** is the variety that is used internally in medicine as an anthelmintic, antiseptic, and stimulant. It is prepared by purifying spirit of turpentine with a solution of sodium hydroxide. It is a clear, colorless, volatile, transparent liquid with a characteristic odor and taste, and is highly inflammable. It is soluble in alcohol. Locally the oil is used as an antiseptic and rubefacient.

Other volatile oils used in medicine are: bitter almond, anise, orange-peel, birch, cade, cajuput, cloves, chenopodium, cinnamon, caraway, coriander, eucalyptus, fennel, wintergreen, pennyroyal, juniper, lavender flowers, lemon, peppermint, spearmint, nutmeg, tar, rose, rosemary, santal, sassafras, thyme, and volatile oil of mustard.

All of the volatile oils are more or less antiseptic, stimulant, carminative, irritant, and expectorant.

**Menthol, thymol, and eucalyptol** are derived from oil of peppermint, oil of thyme, and oil of eucalyptus.

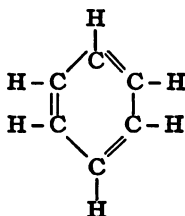
## THE BENZENES

Of the members of the fifth or last series, the benzenes, **benzene** is most important. This compound must not be confused with "benzin" of the paraffins or fatty series.

### BENZENE ( $C_6H_6$ )

"Phene"

"Benzol"

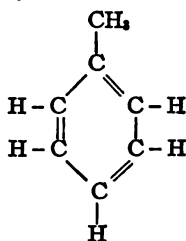


This is a colorless, volatile, very inflammable liquid, with a peculiar odor. It is insoluble in water. It is obtained by distillation from coal-tar.

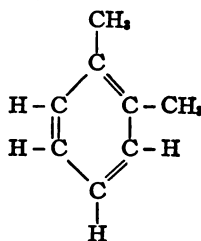
Benzene is a good solvent for iodine, sulphur, phosphorus, resins, oils and fats. Many dyes, antiseptics and antipyretics are derived from it.

Other members of this series found in coal-tar are:

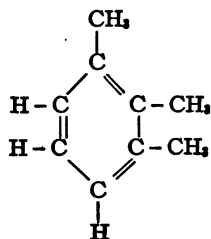
**TOLUENE** ( $C_7H_8$ ), also known as  
*methyl benzene*:



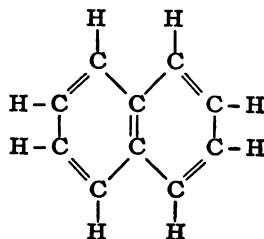
**XYLENE** ( $C_8H_{10}$ ), also known as  
*dimethyl benzene*:



**CUMENE** ( $C_9H_{12}$ ), also called *tri-*  
*methyl benzene*:



**NAPHTHALENE** ( $C_{10}H_8$ ), or "Coal-  
tar Camphor" or "Tar Balls":





## CHAPTER XV

### DERIVATIVES OF THE HYDROCARBONS

#### HALOGEN SALTS

CHLORINE, bromine, and iodine have the power of replacing one or more of the hydrogen atoms of hydrocarbons forming salts.

##### METHYL CHLORIDE



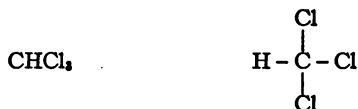
This is a colorless, combustible gas with an ethereal odor. It burns with a green flame. The gas can be readily liquefied, and in this form may be used as a refrigerant, local anæsthetic.

##### ETHYL CHLORIDE



A colorless, mobile liquid, slightly soluble in water, but easily soluble in alcohol. Its solution in alcohol is known as "*chloric ether*." It is used as a local anæsthetic.

##### CHLOROFORM

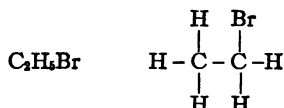


This is a liquid, clear, heavy, colorless, very volatile, with an ethereal odor and a burning, sweet taste. Its specific gravity is about 1.5. It is slightly soluble in water, soluble in all proportions in alcohol, ether, etc. It is not inflammable like *ether*.

In medicine it is used as a counter-irritant and general anæsthetic. It is depressant to the circulation, respiration, and tem-

perature. It is used also as a solvent for resins, camphor, alkaloids, rubber, phosphorus, iodine, and fats.

#### ETHYL BROMIDE



Ethyl bromide is a heavy, colorless liquid with a chloroform-like odor and a burning taste. It is insoluble in water. The compound has been used as a general anæsthetic.

#### BROMOFORM



This compound is a heavy, colorless, volatile, transparent liquid with an ethereal odor and a sweet taste. It is slightly soluble in water, but is very soluble in alcohol, ether, etc.

Bromoform is somewhat used in medicine as an anæsthetic, nervine, and sedative.

#### iodoform



Iodoform comes in the form of lemon-yellow crystals with a peculiar, penetrating, persistent odor and an unpleasant, slightly sweetish taste. It is nearly insoluble in water, but is soluble in ether, chloroform, etc.

It is used in medicine as an antiseptic, but is objectionable because of its odor.

#### ALCOHOLS

Alcohols are hydroxides of hydrocarbon radicals, and are distinguished by the ending *-ol*. According to the number of  $\text{—OH}$  groups, they are termed *monatomic*, *diatomic*, and *triatomic*. They are also classified as *primary* (group  $\text{CH}_2\text{OH}^1$ ), *secondary* (group

$\text{CHOH}^{\text{II}}$ ), and *tertiary* (group  $\text{COH}^{\text{III}}$ ). The alcohols are readily oxidized. The *primary* may be oxidized to **aldehydes** and **mono-basic acids**; the *secondary* to **ketones**; and the *tertiary* to simpler compounds.

#### METHYL ALCOHOL

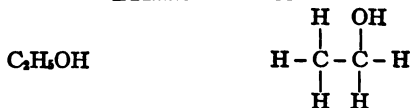


“*Wood Alcohol*”      “*Wood Spirits*”      “*Carbinol*”

This compound is prepared chiefly by the destructive distillation of wood, and is a by-product in the manufacture of beet sugar. It is a colorless, volatile, inflammable liquid, having a disagreeable odor, a burning taste, and a specific gravity of 0.8. It boils at  $66^\circ \text{C}$ . It is miscible with water in all proportions, and burns with a non-luminous flame.

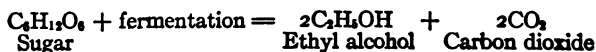
Methyl alcohol readily dissolves fatty oils, camphors, resins, and fats. It is used also in the manufacture of varnishes and dyes and for heating purposes. It is one of the components of “denatured alcohol.” “Wood alcohol” is a poison and must not be confused with “grain alcohol.” When taken internally in poisonous quantities, its exhilarating effect is quickly followed by vertigo, nausea, vomiting, headache, dilated pupils, delirium, *persistent* coma, and death. Should the patient recover there is danger of partial or total blindness, due to atrophy of the optic nerve. In cases of poisoning, the stomach should be emptied, artificial respiration resorted to, and strychnine administered.

#### ETHYL ALCOHOL



“*Alcohol*”      “*Grain Alcohol*”      “*Spirit of Wine*”

Ethyl alcohol is formed by the alcoholic fermentation of sugar and subsequent distillation.



It is a transparent, colorless, hygroscopic, volatile liquid with an agreeable odor and burning taste. Its specific gravity is about 0.8 (92.3 per cent.). It burns with a pale blue, non-luminous flame, and boils at 78.5° C. It is miscible with water, ether, chloroform, etc., in all proportions. When alcohol and water are mixed there is a rise in temperature, and the resultant mixture is less in bulk than that of the two before mixing.

**Alcohol**, U. S. P., should contain about 92.3 per cent. by weight or about 94.9 per cent. by volume of absolute ethyl alcohol.

**Absolute Alcohol**, U. S. P., should contain not more than 1 per cent. by weight of water.

**Diluted Alcohol**, U. S. P., should contain about 41.5 per cent. by weight or 48.9 per cent. by volume of absolute ethyl alcohol.

**Denatured alcohol** is free from internal revenue tax, and is used in the arts and industries for fuel, light, and power, but is rendered unfit for beverages and *internal* medicinal purposes. Denatured alcohol may be prepared by mixing ethyl alcohol with methyl alcohol and benzin, or methyl alcohol and pyridine bases (pyridine ( $C_5H_5N$ ) is a constituent of bone-oil). Hospitals are permitted to denature alcohol by adding such substances as camphor, thymol, boric acid, bichloride of mercury, etc., which render it unfit for a beverage, but not for external use.

**Whiskey** ("*Spiritus Frumenti*," U. S. P.) is an alcoholic liquid obtained by distilling the mash of fermented grain, and should contain, if U. S. P., from 44 to 55 per cent. of ethyl alcohol by volume.

**Brandy** ("*Spiritus Vini Gallici*," U. S. P.) is an alcoholic liquid obtained by the distillation of wines, and should contain, if U. S. P., from 46 to 55 per cent. of ethyl alcohol by volume.

**Gin** is ordinary grain alcohol distilled and aromatized with juniper berries. It contains from 30 to 40 per cent. of alcohol.

**White wine** ("*Vinum Album*," U. S. P.) is an alcoholic liquid obtained by fermenting the juice of fresh grapes which have been deprived of their seed, skins, and stems. It should contain not less than 8.5 nor more than 15 per cent. of alcohol by volume.

**Red wine** (" *Vinum Rubrum*," U. S. P.) is an alcoholic liquid obtained by fermenting the juice of fresh, red-colored grapes. The alcoholic percentage requirement is the same as for white wine.

**Sparkling wines** are those which are more or less heavily charged with carbon dioxide gas, either naturally or otherwise. Champagne is an example of this class of wine.

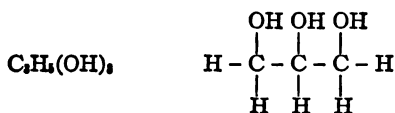
**Still wines** are those in which there is but little or no carbon dioxide remaining, so that they do not effervesce.

**Dry wines** are those in which the sugar has been exhausted by fermentation.

**Sweet wines** are those which possess considerable amounts of unfermented sugar.

Alcohol is a food, a narcotic, a stimulant, a gastric stimulant, and an antiseptic. Diluted with water, it is used as a lotion to reduce fevers, cleanse the skin, and to prevent and heal bed-sores. Because of its solvent and preservative action, it is used in the manufacture of spirits, fluidextracts, tinctures, etc. In the forms of wines, brandies, etc., it is used as a beverage.

#### GLYCERIN



" *Propenyl Hydroxide* "

" *Glycerol* "

Glycerin is a liquid obtained by the decomposition of animal and vegetable fats or fixed oils, and should contain not less than 95 per cent. of absolute *glycerol*, which is a *triatomic alcohol*.

It is a colorless, syrupy, clear liquid, with no odor, but having a sweet taste. Its specific gravity is 1.25, and its boiling-point, 290° C. It is hygroscopic and mixes with water and alcohol in all proportions. It is insoluble in ether, chloroform, etc.

When administered by mouth or rectum it acts as a laxative. It is of limited value as a medicine, but is one of the most useful solvents and preservatives, and is therefore employed in the manufacture of a large number of medicinal preparations. It is of par-

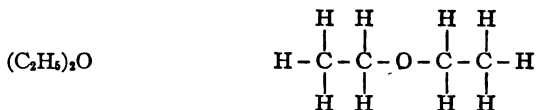
ticular value for increasing the solubility of phenol, tannic and boric acids. It is also employed in the manufacture of nitroglycerin, wines, beers, lubricants, elastic glues, and cements.

## ETHERS AND ESTERS

**Ethers** are formed by the replacement of the hydrogen of the hydroxyl groups in alcohols by hydrocarbon radicals, or may be looked upon as hydrocarbon oxides; as  $(C_2H_5)_2O$ , ethyl oxide.

**Esters** or "*ethereal salts*" are formed by the replacement of the hydrogen of the hydroxyl or carboxyl ( $COOH$ ) groups in acids by hydrocarbon radicals, and may be looked upon as salts; as  $C_2H_5NO_2$ , ethyl nitrite.

### ETHYL ETHER



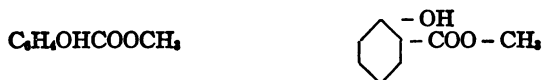
"*Ethyl Oxide*"    "*Ether*"    "*Sulphuric Ether*"

Ether is manufactured by heating a mixture of alcohol and sulphuric acid. It is a transparent, colorless, mobile, highly volatile and inflammable liquid, with a characteristic odor and a burning, sweetish taste. Its specific gravity is about 0.8, and its boiling-point,  $35^\circ C$ . The vapors explode violently when ignited. It is soluble in alcohol and chloroform, and dissolves in 10 volumes of water. It is a good solvent for resins, fats, many alkaloids, bromine, iodine, and phosphorus.

Beside its use as a solvent, ether is used in medicine and surgery as an anæsthetic. It should be remembered that on account of the inflammability of its vapors ether should be handled carefully and cautiously in the presence of open fire or flame.

**Spirit of Ether**, U. S. P., is a mixture of 325 parts of ether and 675 parts of alcohol.

**Compound Spirit of Ether**, U. S. P. ("*Hoffmann's Anodyne*"), contains some ethereal oil in addition to the ether and alcohol.

**METHYL SALICYLATE***"Artificial Oil of Wintergreen"*

This is the principal constituent of oil of wintergreen and oil of betula. It is an *ester* that may be produced synthetically, and occurs as a colorless liquid, with an aromatic, wintergreen odor and a sweetish taste. It is sparingly soluble in water, soluble in alcohol and carbon disulphide.

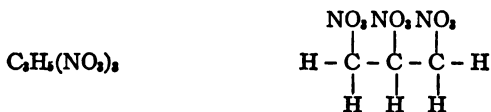
The compound is used in the treatment of rheumatism and as a flavoring agent.

**Spirit of Wintergreen**, U. S. P., should contain 5 per cent. of oil of wintergreen dissolved in alcohol.

**NITROUS ETHER**

This compound (*Ethyl Nitrite*) may be prepared by distilling a mixture of ethyl alcohol, sulphuric acid, and sodium nitrite. **Spirit of Nitrous Ether**, U. S. P. (*"Sweet Spirit of Nitre"*), contains 4 parts of this compound with 96 of alcohol.

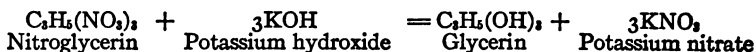
Nitrous ether is a diuretic, diaphoretic, and sedative.

**NITROGLYCERIN***"Pyroglycerin"**"Glyceryl Trinitrate"*

Nitroglycerin is prepared from glycerin, nitric and sulphuric acids. It is a yellow, highly explosive liquid, soluble in alcohol.

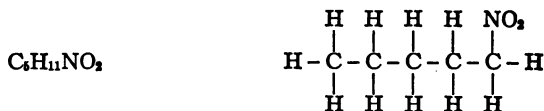
**Spirit of Nitroglycerin**, U. S. P. (*"Spirit of Glonoin"*), is a 1 per cent. solution of the compound in alcohol. The solution

has the odor and taste of alcohol. Extreme care should be observed in handling the preparation. If any of the liquid is spilled, some alcoholic solution of potassium or sodium hydroxide should be immediately poured upon it. The alkali solution causes the splitting up of the explosive compound into harmless glycerin and potassium or sodium nitrate.



This compound dilates the blood-vessels, and acts as an anti-spasmodic. If full doses are given, it gives rise to violent headaches. When the compound is mixed with sawdust or infusorial earth it is sold under the name "dynamite."

#### AMYL NITRITE



Amyl nitrite is a pale yellow liquid with a strong, ethereal odor and a pungent, aromatic taste. The official amyl nitrite contains about 80 per cent. of this compound. It is almost insoluble in water, but is miscible with alcohol and ether. It is also very volatile and inflammable. It usually comes in sealed glass bulbs, each containing a few drops of the liquid.

In medicine it is used by inhalation as a quick stimulant.

#### PHENYL SALICYLATE



Salol may be prepared by heating salicylic acid in an atmosphere of carbon dioxide whereby it loses water and carbon dioxide. It occurs as a white, crystalline powder, with a faint, aromatic odor and a slight, characteristic taste. It is sparingly soluble in water, but is soluble in alcohol, ether, and chloroform.



The compound is employed in medicine as an intestinal and urethral antiseptic and as an antirheumatic. In pharmacy it is used for coating pills intended to act within the intestines.

## FATS AND OILS

These compounds are esters of glycerol and the higher fatty acids, mainly oleic ( $C_{17}H_{33}COOH$ ), palmitic ( $C_{15}H_{31}COOH$ ), and stearic ( $C_{17}H_{35}COOH$ ).

All fats are lighter than water, cannot be distilled, and in the pure condition most of them are colorless, but upon aging become yellowish and develop a strong odor (*i.e.*, become *rancid*). When a fat or oil becomes rancid, decomposition takes place spontaneously, with the result that the fatty acid is set free. Upon exposure to air some fatty oils absorb oxygen, developing enough heat to set fire to wool and cotton tissue soaked with the oil. Such oils are known as "drying oils," and become thick and finally dry to a resinous mass, which makes them valuable for painting and varnishing.

## VEGETABLE OILS

The following are the more important oils of vegetable origin: olive, almond, rape, mustard, cotton-seed, beech-nut, linseed, castor, croton, palm, cocoanut, palm-nut and cocoa butter, and Japan wax.

## ANIMAL OILS

Of the oils of animal origin, the following are the more important: lard, neat's-foot, bone, tallow, whale, seal, cod-liver, and sperm.

## ANIMAL FATS AND WAXES

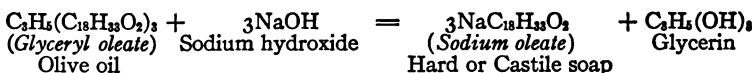
Tallow, lard, bone and wool, butter fats, oleomargarine, stearine, spermaceti, beeswax, and Chinese wax.

Oleomargarine and butterine are mixtures of pure fats which have been churned with some sweet milk, artificially colored, salted, and sold as butter substitutes. If properly prepared they are quite wholesome.

## SOAPS

When fats and oils are treated with alkali hydroxides the glycerin is set free and a **soap** is formed. Such a process is called "*saponification*."

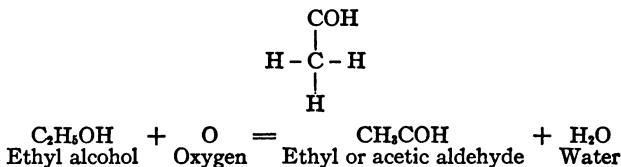
Soaps may be divided into **hard** and **soft** soaps. **Hard** soaps are those in which *sodium* is the base; **soft**, those in which *potassium* is the base. Example:



Soaps are soluble in water and alcohol. Potassium or soft soaps are usually yellowish, but are frequently tinted green artificially and called "**green soap**." Soaps are excellent cleansing agents, and are also more or less disinfectant.

## ALDEHYDES

These compounds are formed by dehydrogenating alcohols, usually by oxidation. For example: Ethyl or acetic aldehyde.

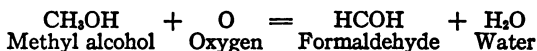


## FORMALDEHYDE



"*Methyl Aldehyde*"

This compound is prepared by the oxidation of wood or methyl alcohol:



It is a colorless gas with a pungent odor, soluble in water. A 40 per cent. aqueous solution is known as "**formalin**." The official

solution of formaldehyde contains about 37 per cent. of the gas.

It is an antiseptic of great power, a disinfectant, a preservative for foods and drinks, a deodorizer, and a cauterizing agent. It is also used in embalming fluids and as a preservative for specimens.

### PARALDEHYDE ((CH<sub>3</sub>COH)<sub>3</sub>)

Paraldehyde is a colorless, transparent liquid with a strong, characteristic odor and a burning taste. It is soluble in water and miscible in all proportions with alcohol.

In medicine it is used as a nerve sedative and hypnotic.

### CHLORAL (CCl<sub>3</sub>COH)

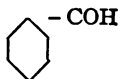
*" Trichloraldehyde "*

Chloral is a colorless, oily liquid with a sharp odor and an acrid taste.

**Chloral Hydrate**, U. S. P. (*" Knock-out drops," " Chloral "*), consists of chloral united with a molecule of water: CCl<sub>3</sub>COH.H<sub>2</sub>O. It is a white, crystalline *solid*, having an aromatic odor and a bitter, caustic taste. It is slowly volatile, soluble in water, alcohol, and ether. Upon mixing with phenol, thymol, and camphor it forms a liquid. The compound is a valuable hypnotic.

### BENZALDEHYDE

C<sub>6</sub>H<sub>5</sub>COH



*" Oil of Bitter Almonds "*

Benzaldehyde is formed when the glucoside, *amygdalin*, and the ferment, *emulsin*, are brought together in the presence of water. It is a colorless liquid with the odor of bitter almond and a burning taste. It is sparingly soluble in water, but freely soluble in alcohol. The *crude* "oil" contains hydrocyanic (*" prussic "*) acid, which makes it poisonous. The purified product is non-poisonous.

It is used as a flavoring agent and in the manufacture of dyes.

**KETONES**

These are oxidation products of *secondary* alcohols and are distinguished by the  $\text{CO}^{\text{II}}$  radical.

There is but one worthy of mention here.

**ACETONE**

*" Dimethyl-ketone "*

This compound is prepared by the dry distillation of calcium acetate ( $\text{Ca}(\text{C}_2\text{H}_3\text{O}_2)_2$ ). It is a colorless, transparent liquid with a pleasant, minty odor and a sharp taste. It is soluble in water, alcohol, and ether.

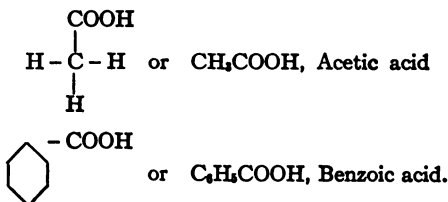
Its principal use is as a solvent for resins in varnishes, and as a source of sulphonal and trional.

## CHAPTER XVI

### DERIVATIVES OF THE HYDROCARBONS

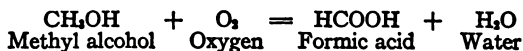
#### ORGANIC ACIDS

ALL organic acids contain the fundamental group  $\text{COOH}$ , known as "*carboxyl*." According to the number of carboxyl groups, they are monobasic, dibasic, or tribasic. By replacing the hydrogen of the carboxyl groups with metals, various salts are formed. The organic acids include both solids and liquids. Examples:



#### FORMIC ACID ( $\text{HCOOH}$ )

Formic acid occurs in red ants, fir cones, the bristles of stinging nettles, and the venom of bees and hornets. It may be prepared by the oxidation of methyl alcohol according to the following equation:



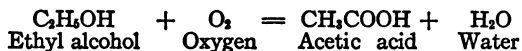
The acid is a colorless liquid with a penetrating odor and irritant action on the skin. It is soluble in water and alcohol. Its salts are known as "formates." An alcoholic solution of the acid is known as "*Spiritus Formicarium*."

It acts as a caustic and powerful antiseptic.

#### ACETIC ACID ( $\text{CH}_3\text{COOH}$ )

Acetic acid is found in some plant juices and is formed during vegetable decay. It may be manufactured by "acetic fermentation" or the slow oxidation of weak alcoholic solutions. The

product of either process is known as "**vinegar**," which contains from 3 to 10 per cent. of absolute acetic acid.



It is a clear, colorless liquid with a strong, vinegar-like odor and an acid taste. It is miscible with alcohol and water in all proportions. Upon application of heat it completely volatilizes.

Its salts are known as "acetates."

**Acetic Acid**, U. S. P., is 36 per cent.; **Diluted Acetic Acid**, U.S.P., is 6 per cent.; and **Glacial Acetic Acid**, U. S. P., is 99 per cent.

In medicine diluted acetic acid is used as a lotion for night-sweats and to control slight hemorrhages. Glacial acetic acid is employed as an escharotic. Diluted acetic acid corresponds to commercial vinegar, which is used in large quantities for domestic purposes.

**Test for Acetic Acid.**—When the acid is neutralized with sodium hydroxide and a small amount of solution of ferric chloride added, a deep red color is produced.

#### TRICHLORACETIC ACID ( $\text{CCl}_3\text{COOH}$ )

This comes in the form of white, deliquescent crystals with a characteristic odor. It is very soluble in water, alcohol, and ether.

The acid is used as a cauterizing agent.

#### BUTYRIC ACID ( $\text{C}_4\text{H}_7\text{COOH}$ )

This is the characteristic acid of butter, where it exists *in combination* if the butter is fresh. The acid is set free when butter becomes rancid. Rancid butter may be "*renovated*" by adding sodium bicarbonate, which neutralizes the free butyric acid.

#### LACTIC ACID ( $\text{C}_3\text{H}_5\text{OHCOOH}$ )

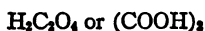
Lactic acid occurs in opium, the gray matter of the brain, in the gastric juice, and in sauerkraut. It may be manufactured by "lactic fermentation" of sugar, and is therefore found in sour milk, koumiss, etc.

The official acid should contain not less than 75 per cent. of absolute acid. It occurs as a colorless, syrupy liquid, without odor and having an acid taste. It is slightly deliquescent, and is soluble in water, alcohol, and ether.

The acid is rarely given internally, but is applied externally to warts, etc.

**Test for Lactic Acid.**—A few drops of the acid added to some very diluted solution of ferric chloride yield a yellow color.

#### OXALIC ACID



Oxalic acid is found in many plants, such as dock, beets, tomatoes, and rhubarb, as salts. It may be prepared by the oxidation of starch or sugar with nitric acid.

It is a white, crystalline solid with an acid taste and no odor. Water dissolves it readily. The compound is a *violent poison*. It has been frequently mistaken for Epsom salt (magnesium sulphate), poisoning and sometimes death resulting. Calcium salts, such as plaster, or lime water may be used as antidotes; also magnesia.

The acid is used in dyeing, to clean metallic utensils, as a cleaning and bleaching agent by manufacturers of straw hats, to remove rust and ink stains, in tanning, and also to remove the stain of potassium permanganate from the hands.

**Test for Oxalic Acid.**—The addition of a few drops of calcium chloride solution to a neutralized oxalic acid solution gives a white precipitate.

#### TARTARIC ACID



Tartaric acid is found in the juice of grapes, both in the free and combined condition. It is usually manufactured from "argols," a deposit in wine-casks, which contain potassium acid tartrate ( $\text{KHC}_4\text{H}_4\text{O}_6$ ).

It occurs as colorless crystals or as a white, crystalline powder, having no odor, but with an acid taste. It is soluble in water and alcohol.

Being dibasic, it forms three kinds of salts ("tartrates"): neutral ( $K_2C_4H_4O_6$ ), acid ( $KHC_4H_4O_6$ ), and double ( $KNaC_4H_4O_6$ ).

The acid is employed in making acidulous, refrigerant drinks. It is one of the constituents of "Seidlitz powders" and of effervescing salts. It is also used in the printing and dyeing industries, in the manufacture of baking powders, and by confectioners.

**Test for Tartaric Acid.**—Upon neutralizing a solution of the acid and adding some solution of calcium chloride, a white precipitate is produced, which, after being washed, will dissolve in a solution of potassium hydroxide. From the latter solution a precipitate is thrown out upon boiling.

#### CITRIC ACID



✓  
"Fruit Acid"

Citric acid occurs in the juice of limes and lemons, from which it is prepared. It occurs as colorless, odorless crystals with an agreeable acid taste. It is soluble in both alcohol and water.

Its salts are known as "citrates."

It is used in medicine as a diuretic, refrigerant, and flavoring agent. It is frequently used in making "lemonade" and "fruit syrups."

**Test for Citric Acid.**—Upon neutralizing a solution of the acid and adding some solution of calcium chloride, a white precipitate is produced which is *insoluble* in solution of potassium hydroxide. (*Compare with Test for Tartaric Acid.*)

#### BENZOIC ACID



This acid occurs in the free state in a number of resins and balsams. It comes in the form of white, lustrous scales or needles that are nearly odorless and have an acid, pungent taste. It is volatile and its vapors excite sneezing. It is slightly soluble in water, but is freely soluble in alcohol.

Its salts are known as "benzoates."



It is used in medicine to overcome alkalinity of the urine, and as an antiseptic and expectorant. The acid and its salts are used as food preservatives.

**Test for Benzoic Acid.**—If a solution of the acid is neutralized and some solution of ferric chloride added, a flesh-colored precipitate is formed.

#### SALICYLIC ACID



*"Oxy-Benzoic Acid"*

Salicylic acid is found in combination in the oils of wintergreen and birch. It is manufactured in large quantities from phenol.

It occurs as light, white, fine needles, or as a bulky, white powder, without odor, but having a sweetish taste. It is slightly soluble in water, but readily soluble in alcohol.

Its salts are known as "salicylates."

It is used in medicine as an antiseptic and dusting powder, and for softening and removing horny layers of the skin. It is also used as a preservative for fruit, beer, wine, meat, etc.

**Test for Salicylic Acid.**—The addition of some solution of ferric chloride to a solution of the acid gives a violet coloration.

#### TANNIC ACID



*"Digallic Acid"*      *"Tannin"*      *"Gallotannic Acid"*

This acid is found in nutgalls, sumach, tea, etc., from which it may be prepared. It is a light, yellowish, amorphous powder, or comes in the form of scales, without odor and having a strong, astringent taste. It is very soluble in water and alcohol.

Its salts are known as "tannates."

In medicine it is used as an astringent, styptic, hæmostatic, and antiseptic. It is also used in tanning and in the manufacture of inks, dyes, and artificial horn and tortoise-shell.

**Test for Tannic Acid.**—The addition of a solution of ferric chloride produces an inky-black coloration. The acid will coagulate a solution of albumin.

**GALLIC ACID**

Gallic acid is found in nutgalls, tea, sumach, etc., from which it may be prepared. It occurs in the form of fawn-colored or nearly white, silky needles, without odor and having an astringent, slightly acid taste. It is soluble in water and alcohol.

Its salts are known as "gallates."

It is used as a hæmostatic, antiseptic, and astringent.

**Test for Gallic Acid.**—The addition of a solution of ferric chloride produces a blue-black coloration. The acid does not coagulate albumin. (*Compare with Test for Tannic Acid.*)

**ACETYL-SALICYLIC ACID** ( $\text{C}_9\text{H}_8\text{O}(\text{CH}_3\text{CO})\text{COOH}$ )

*"Aspirin"*

This comes in the form of colorless needles, which have no odor but an acidulous taste. It is soluble in 100 parts of water, and freely soluble in alcohol and ether.

It is used as an antipyretic and antirheumatic.

**ORGANIC SALTS****ACETATES**

**Potassium acetate** ( $\text{KC}_2\text{H}_3\text{O}_2$ ): a white, deliquescent salt, without odor, having a saline taste, and soluble in water and alcohol.

**Sodium acetate** ( $\text{NaC}_2\text{H}_3\text{O}_2$ ): colorless, odorless crystals having a saline taste. It is efflorescent, soluble in water and less soluble in alcohol.

**Lead acetate** ( $\text{Pb}(\text{C}_2\text{H}_3\text{O}_2)_2$ ), commonly called "*Sugar of lead*": colorless, shiny crystals having a faint acetous odor and a sweetish, astringent taste. It is efflorescent and soluble in water and alcohol.

**Zinc acetate** ( $\text{Zn}(\text{C}_2\text{H}_3\text{O}_2)_2$ ): soft, white, pearly plates, having a faint, acetous odor and an astringent, metallic taste. The salt is efflorescent and soluble in both water and alcohol.

**Uses.**—The sodium and potassium salts are diuretic and cathartic. Lead and zinc acetates are astringent and styptic. The zinc salt is also used as an emetic and antiseptic. The sodium

and zinc compounds are used in dyeing and the manufacture of pigments. Zinc acetate is also used for preserving wood and to produce a glaze on porcelains.

### TARTRATES

**Potassium acid tartrate** ( $\text{KHC}_4\text{H}_4\text{O}_6$ ), potassium bitartrate or "*Cream of Tartar*": small, colorless, odorless crystals, or a white powder, having an acid taste. The compound is sparingly soluble in water and alcohol. This is the most important tartrate and is used in large quantities in the manufacture of baking powders. It is used in medicine as a diuretic and laxative.

**Potassium and sodium tartrate** ( $\text{KNaC}_4\text{H}_4\text{O}_6$ ), known as "*Rochelle Salt*" and "*Sal Seignette*": this double salt forms large, colorless, odorless crystals which have a cool, saline taste. The salt is slightly efflorescent, and is soluble in water and alcohol. It is one of the ingredients of Seidlitz powders.

**Antimony and potassium tartrate** ( $\text{K}(\text{SbO})\text{C}_4\text{H}_4\text{O}_6$ ), "*Tartar Emetic*": this salt usually comes in the form of a white, odorless, crystalline powder having a sweet, disagreeable, metallic taste. It is soluble in water, but insoluble in alcohol. The salt is an active poison in large doses. It is used in medicine as an emetic and expectorant.

### CITRATES

**Potassium citrate** ( $\text{K}_3\text{C}_6\text{H}_5\text{O}_7$ ): this forms colorless, odorless crystals, or comes in the form of a white, granular powder, with a saline, cooling taste. It is soluble in water and sparingly so in alcohol.

**Sodium citrate** ( $\text{Na}_3\text{C}_6\text{H}_5\text{O}_7$ ): a white, granular, odorless powder having a cooling, saline taste. It is soluble in water, but sparingly soluble in alcohol.

**Lithium citrate** ( $\text{Li}_3\text{C}_6\text{H}_5\text{O}_7$ ): colorless, odorless crystals, or a white, odorless powder, having an alkaline taste. It is deliquescent, soluble in water, and insoluble in alcohol.

**Bismuth citrate** ( $\text{BiC}_6\text{H}_5\text{O}_7$ ): a white, odorless, tasteless, amorphous powder. It is insoluble in water and alcohol.

**Uses.**—The first three citrates are used as diuretics, antipyretics, antilithics, and refrigerants. The bismuth salt is a stomachic and astringent.

### BENZOATES

**Ammonium benzoate** ( $\text{NH}_4\text{C}_7\text{H}_5\text{O}_2$ ): a white, odorless, crystalline powder having a saline taste. It is soluble in water and alcohol.

**Lithium benzoate** ( $\text{LiC}_7\text{H}_5\text{O}_2$ ): a white, odorless, light powder with a sweetish taste. It is soluble in water and alcohol.

**Sodium benzoate** ( $\text{NaC}_7\text{H}_5\text{O}_2$ ): a white, odorless, crystalline, or amorphous powder with a sweetish, astringent taste. It is soluble in water.

**Uses.**—The ammonium salt is expectorant, antipyretic, and diuretic. The lithium and sodium salts are antirheumatic, diuretic and antipyretic.

### SALICYLATES

**Ammonium salicylate** ( $\text{NH}_4\text{C}_7\text{H}_5\text{O}_3$ ): a white, odorless, crystalline powder with a saline, bitter taste. It is soluble in alcohol and water.

**Lithium salicylate** ( $\text{LiC}_7\text{H}_5\text{O}_3$ ): a white or grayish, odorless powder with a sweet taste. The salt is deliquescent and dissolves in water and alcohol.

**Sodium salicylate** ( $\text{NaC}_7\text{H}_5\text{O}_3$ ): a white or pinkish, odorless powder with a sweetish taste. It is soluble in water and alcohol.

**Strontium salicylate** ( $\text{Sr}(\text{C}_7\text{H}_5\text{O}_3)_2$ ): a white, odorless, crystalline powder with a sweetish, saline taste. It is soluble in water and alcohol.

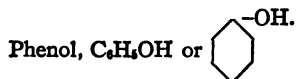
**Bismuth sub-salicylate**: this salt is of variable chemical composition. It occurs as a whitish, amorphous or crystalline, odorless, tasteless powder. It is almost insoluble in water.

**Mercury salicylate** (basic) ( $\text{HgC}_7\text{H}_4\text{O}_2$ ): a white powder, insoluble in water and alcohol. The compound is used especially in the treatment of syphilis, being injected in suspension.

**Uses.**—The salicylates are used as antiseptics, antirheumatics, and antipyretics. The ammonium salt is also expectorant, while the bismuth salt is also astringent.

## PHENOLS

Phenols are compounds in which one or more atoms of hydrogen of benzene ( $C_6H_6$ ) are replaced by hydroxyl (OH). Example:



### PHENOL ( $C_6H_5OH$ )

“ *Carbolic Acid* ”

This compound is manufactured from coal-tar by fractional distillation. It appears as colorless crystals, with a characteristic odor and a sweetish, burning taste. It cauterizes and whitens the skin. Phenol is soluble in about 20 parts of water. Glycerin increases the solubility in water. It is volatile and its vapors are inflammable. Upon the addition of 8 per cent. of water it readily liquefies. When triturated with camphor, menthol, thymol, resorcinol, acetanilid, etc., a liquid mixture results. It coagulates albumin and collodion.

Phenol is a violent, caustic protoplasmic poison, destructive to animal and vegetable life. In the treatment of poisoning by this compound alcohol, whiskey, zinc sulphate, white of egg, milk of lime, olive and castor oils with magnesia in suspension are given as antidotes.

It is used in medicine as a disinfectant, antiseptic, and caustic.

The official **Liquefied Phenol** contains 86.4 per cent., and the official **Ointment** (“*carbulated salve*” or “*carbulated vaseline*”) contains 3 per cent. of phenol.

### CRESOL

“ *Kresol* ”                      “ *Cresylic Acid* ”



Cresol is obtained from coal-tar by fractional distillation at a temperature higher than that used for the distillation of phenol. It is a straw-colored liquid, with a phenol-like odor, and becomes brown upon exposure to light. It is soluble in 60 parts of water. Alkaline solutions increase the solubility.

The compound is used as an antiseptic and disinfectant. It is less caustic than phenol and is less rapidly absorbed. **Compound Solution of Cresol** is official.

### CREOSOTE

“ *Kreosote* ”      “ *Wood Creosote* ”      “ *Oil of Smoke* ”

This is a mixture of phenols obtained by fractional distillation from *wood-tar*. It is a yellow, oily liquid, with a smoky odor and a burning taste. It is slightly soluble in water.

In medicine the compound is used as an expectorant, antiseptic, and antitubercultic. **Creosote Water**, containing 10 per cent. of creosote, is official.

This creosote should not be confused with the “ **coal-tar creosote** ” obtained from coal-tar and used for technical and external purposes. Wood creosote, in small doses, is harmless, while coal-tar creosote is decidedly poisonous.

### RESORCINOL ( $C_6H_4(OH)_2$ )

“ *Resorcin* ”

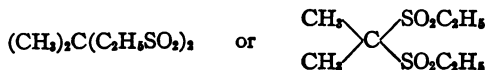
Resorcinol occurs in the form of white crystals having a faint odor and sweetish taste. It is soluble in water and alcohol. Upon exposure to light it becomes pinkish.

The compound is slightly poisonous. It is used in medicine as an antiseptic. It is also used in the manufacture of dyes.

## SULPHUR DERIVATIVES

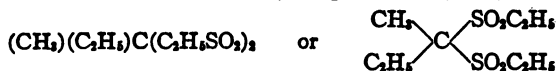
### SULPHONMETHANE

“ *Sulphonal* ”      “ *Diethylsulphon-dimethylmethane* ”



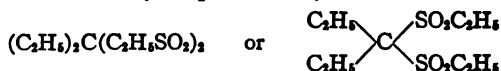
This is a white, crystalline, odorless, tasteless compound, manufactured from acetone. It is soluble in 15 parts of hot and 360 parts of cold water, and dissolves with difficulty in alcohol.

In medicine it is used as a hypnotic and sedative.

**SULPHONETHYLMETHANE**“ *Trional* ”“ *Diethylsulphon-methylethylmethane* ”

This compound occurs as colorless, odorless, tasteless, lustrous crystals, soluble in hot water, alcohol and ether.

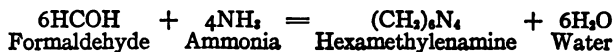
It is used in medicine as a hypnotic and sedative.

**TETRONAL**“ *Diethylsulphon-diethylmethane* ”

“ Tetronal ” also occurs as colorless, lustrous crystals, soluble in hot water, alcohol and ether. It is used for the same purposes as “ sulphonal ” and “ trional. ”

**COMPOUNDS CONTAINING NITROGEN****HEXAMETHYLENAMINE**“ *Urotropin* ”“ *Hexamethylene Tetramine* ”“ *Formin* ”

This compound is formed by the action of ammonia on formaldehyde as follows:



It comes in the form of colorless, odorless crystals, soluble in 1.5 parts of water. In the presence of *acid* secretions it is decomposed into formaldehyde and ammonia.

In medicine it is used as a genito-urinary antiseptic.

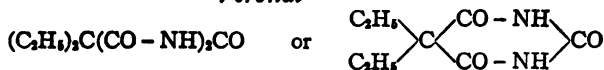
**CARBAMID  $(\text{NH}_2)_2\text{CO}$** “ *Urea* ”

Urea is most likely the first organic compound prepared synthetically. It occurs in the urine and blood of all mammals. It comes in the form of colorless, rhombic prisms, easily soluble in water and alcohol.

It is used as a diuretic.

## DIETHYL-MALONYL-UREA

" Veronal "



" Veronal " occurs as a white, odorless, crystalline powder with a faintly bitter taste. It dissolves in 12 parts of boiling and 145 parts of cold water, and is readily soluble in warm alcohol.

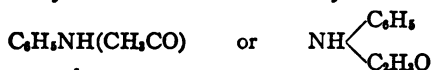
The compound is a valuable hypnotic.

## DERIVATIVES OF BENZENE

## ACETANILID

" Antifebrin "

" Phenylacetamid "

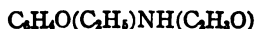


Acetanilid occurs as white, odorless, lustrous crystals, or as a white, crystalline powder, having a greasy feeling. It is soluble in hot water, slightly so in cold water, and readily soluble in alcohol and ether.

In medicine it is used as a local antiseptic and antipyretic. It is a component of the official **Compound Acetanilid Powder**, and is also found in numerous headache powders and wafers.

## ACETPHENETIDIN

" Phenacetine "



This compound occurs as a colorless, odorless, tasteless powder, sparingly soluble in water and readily soluble in alcohol.

It is used as an antipyretic, antirheumatic, and analgesic. The compound is found in many migraine and headache powders. Both Acetanilid and Phenacetine are found in many patent "headache powders." In consequence of the long-continued use of such powders many cases of chronic poisoning and habit have been observed. In such cases failure to take the "powder" is followed by distress and headache. Loss of appetite, gastro-intestinal disturbances, anæmia, special weakness of heart, and cyanotic lips and



face characterize chronic poisoning by these drugs. The cyanosis is caused in part by changes in the blood-coloring matter, and the anæmia by the destruction of red blood-corpuscles.

### TRINITRO-PHENOL

" *Picric Acid* "

" *Carbazotic Acid* "



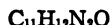
This compound is formed by the action of nitric acid on silk, wool, indigo, etc., but is usually manufactured on a large scale by slowly adding phenol to fuming nitric acid.

It forms yellow, odorless, bitter crystals which are slightly soluble in water. The compound is very poisonous.

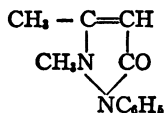
Trinitro-phenol is used for dyeing silk and wool, as a precipitant for alkaloids and albumin, and in the manufacture of explosives. It is also employed in the treatment of burns.

### ANTIPYRINE

" *Phenyl-dimethyl-isopyrazolon* "



or



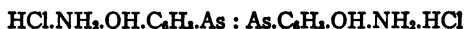
Antipyrine is a white, odorless, crystalline powder having a slightly bitter taste. It is soluble in less than one part of water, also in alcohol, chloroform, and ether.

It is employed in medicine as an antipyretic and styptic. It is another common, harmful ingredient of patent "headache cures."

### PARADIAMIDODIOXYARSENOBENZOL HYDROCHLORIDE

" *Salvarsan* "

" 606 "



This compound is a lemon-yellow, fine powder, which comes in sealed tubes. It is soluble in water.

It is used as a specific remedy for syphilis.

## CHAPTER XVII

### CARBOHYDRATES

**CARBOHYDRATES** are compounds of carbon, hydrogen and oxygen, the latter two elements in the same proportion as in water ( $H_2O$ ), and the carbon in six or some multiple of six. Example: Dextrose,  $C_6H_{12}O_6$ . They make up the bulk of vegetable tissue, and are also found in animal life, such as sugar in milk, bee's honey, etc. All carbohydrates are fermentable or can be converted into substances that are fermentable. They are non-volatile, but are decomposed when heated. They are neutral in reaction, being neither basic nor acid. Most of them are white solids, and with few exceptions are soluble in water. The exact composition of all carbohydrates is not fully understood, although the structure of others is well known.

Carbohydrates may be divided into the following three groups:

#### 1. MONOSACCHARIDES OR SIMPLE SUGARS ( $C_6H_{12}O_6$ )

Dextrose (grape-sugar, starch-sugar and glucose).

Levulose (fructose, formose and diabetin).

Galactose.

Inosit (muscle-sugar).

#### 2. DISACCHARIDES OR COMPLEX SUGARS ( $C_{12}H_{22}O_{11}$ )

Sucrose (cane, beet, sorghum, maple, palm, sweet fruits).

Lactose (milk-sugar).

Maltose (malt-sugar).

Isomaltose (sweet extracts).

#### 3. POLYSACCHARIDES ( $C_6H_{10}O_5$ )<sub>n</sub>

These compounds do not resemble sugars, have no sweet tastes, but can be reduced to sugars.

Cellulose (cellulin).  
Lignin (wood).  
Tunicin (animal cellulose).  
Starch (amylum or glucosin)  
Dextrins (British gum).  
Inulin (levulin).  
Glycogen (liver-starch).  
Raffinose and lactosin.  
Gums.

**DEXTROSE, GRAPE-SUGAR, GLUCOSE ( $C_6H_{12}O_6$ )**

This substance is found in large quantities in the juices of many fruits, as grapes, strawberries, etc. **Dextrose** is found in honey, in small amounts in normal blood, and traces in normal urine, but in diseased conditions as high as 5 per cent. **Grape-sugar** is produced from starch by plants, and may be produced artificially from starch by heating with diluted acids, like sulphuric. **Glucose** usually occurs as a thick syrup, which crystallizes with difficulty, giving crystals that resemble those of cane-sugar. It is soluble in water and is less sweet than cane-sugar. It is prepared by treating corn-starch with an excess of sulphuric acid, removing the excess of acid with chalk, filtering and evaporating to a syrup.

**SUCROSE, CANE-SUGAR, SACCHARUM ( $C_{12}H_{22}O_{11}$ )**

Cane-sugar is found in the juices of many plants, such as the sugar-cane, beets, maple-sap, etc. The plant parts are crushed between rollers, pressing out the juices, which are then heated with milk of lime to precipitate the albuminous substances present. The mixture is then filtered, evaporated to a thin syrup and allowed to crystallize. The product is finally purified by recrystallization.

Cane-sugar occurs as white, hard, small crystals, which are odorless and have a purely sweet taste. It is soluble in water and much less so in alcohol. When heated to about  $210^{\circ}$  C. it is converted to a black, almost tasteless, odorless, porous mass known as "**caramel**," which is used as a coloring agent. When heated to  $160^{\circ}$  C. it fuses, and the liquid upon cooling forms an amorphous, transparent mass, known as "**barley sugar**."

Sugar is employed in the manufacture of syrups, masses, confections, troches, etc. It possesses a high nutritive value, but, since it contains no nitrogen, is incapable alone of sustaining life.

**LACTOSE, SUGAR OF MILK** ( $C_{12}H_{22}O_{11} \cdot H_2O$ )

*" Saccharum Lactis "*

This compound is found almost exclusively in the milk of animals. It is prepared by freeing the milk from fat and casein, evaporating the remaining liquid (the " whey ") to small bulk, and allowing the milk-sugar to crystallize out. It occurs as a white, crystalline, gritty, hard powder or mass, having a faintly sweet taste, but no odor. It is soluble in water and insoluble in alcohol.

Sugar of milk is a food and a diuretic. It is extensively employed in preparing modified milk for bottle-fed infants.

**STARCH** ( $C_6H_{10}O_5$ )<sub>n</sub>

*" Amylum "*

Starch is found very widely distributed in the vegetable kingdom, chiefly in seed of cereals, roots and stems. It is prepared from wheat, rice, potatoes, beans, sago, arrow-root, etc. The vegetable matter is ground up into a fine powder in order to break up the cells containing the starch grains. The powdered mixture is then steeped in water until soft, and is then washed on a sieve under a current of water. The water washes out the starch, leaving the fibrous matter behind. The starch deposits from the wash water and is then purified by further washing.

Starch occurs as a fine, white, amorphous powder, which is slippery to the touch, tasteless, and insoluble in cold water and alcohol. When boiled with water it yields a white jelly, which gives a blue color with iodine.

In medicine starch is used as a demulcent, dusting powder, a diet for invalids and convalescents, and as an antidote in iodine poisoning. It is also used in large quantities for making paste, starching fabrics, etc.

**CELLULOSE** ( $C_6H_{10}O_5$ )<sub>n</sub>*" Plant Fibre "*

The largest portions of the solid parts of plants are cellulose. It is very well fitted for the cellular membrane of plants because it is insoluble in most solvents, is not affected by alkaline or acid liquids, and is tough and flexible. Cotton, hemp, flax, etc., are nearly pure cellulose.

Pure cellulose is a white, translucent, insoluble mass, and does not give a blue color with iodine. If treated with sulphuric acid it swells up and finally dissolves.

Unsize paper (which is chiefly cellulose) dipped into a mixture of sulphuric acid and water, washed and dried, forms what is known as "**parchment paper**."

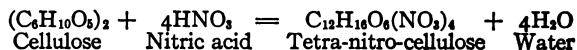
"**Mercerized cotton**" is prepared by placing the material in a strong solution of sodium hydroxide and then washing with water.

"**Absorbent cotton**" (official purified cotton) is nearly pure cellulose. It is prepared from raw cotton by boiling in a weak alkali solution to remove the fat, then bleaching with chlorinated lime, and finally washing with water and drying.

"**Medicated cotton**" is prepared by impregnating absorbent cotton with a glycerin-alcoholic solution of the medicinal agent and drying. The alcohol is volatilized, but the glycerin remains and serves as an adhesive for retaining the medicinal agent on the cotton fibre.

"**Artificial silk**" is made from "*viscose*," which is mercerized cellulose dissolved in carbon disulphide.

**Pyroxylin** ("*soluble gun-cotton*," "*nitro-cellulose*") is chiefly tetra-nitro-cellulose ( $C_{12}H_{16}O_6(NO_3)_4$ ). It is prepared by treating cellulose (cotton) with concentrated nitric and sulphuric acids. The sulphuric acid takes no part in the reaction, but simply absorbs the water formed. The reaction may be represented by the following equation:



Di-, tri-, penta- and hexa-nitro-celluloses may also be manufactured in the same manner by allowing the reactions to proceed

for different lengths of time. The penta-nitro-cellulose ( $C_{12}H_{15}O_5(NO_2)_5$ ) and the hexa-nitro-cellulose ( $C_{12}H_{14}O_4(NO_2)_6$ ) form the highly *explosive gun-cotton*.

**Wood silk** is a mixture of cellulose and nitro-cellulose.

**Celluloid** is prepared by dissolving soluble gun-cotton in molten camphor and cooling to hardness.

**Collodion** is a solution of soluble gun-cotton in a mixture of alcohol and ether.

**Flexible collodion** is a mixture of collodion, castor oil and Canada balsam.

**Styptic collodion** is flexible collodion containing tannic acid.

**Cantharidal collodion** ("blistering collodion") contains the soluble principles of cantharides and possesses blistering properties.

Collodions should be kept in a cool place away from fire.

#### GLYCOGEN ( $C_6H_{10}O_5$ )<sub>n</sub>

"Liver-starch"

"Liver-dextrin"

This compound is found only in animals. It is present in the liver, white blood-corpuscles, embryonic tissues, and muscular tissue. When pure, it is a white, tasteless, starch-like, amorphous substance and is insoluble in alcohol. With water it forms an opalescent solution. It gives a red color with iodine and may be converted into glucose.

#### GLUCOSIDES

This term is applied to a group of organic compounds which, under the influence of ferments, diluted acids or diluted alkalies, take up water and decompose with the formation of glucose and other products. The more important members of this group are: *amygdalin* (from bitter almond, cherry-laurel, etc.), *absinthin* (from wormwood), *digitalin*, (from digitalis), *indican* (a coloring principle), *glycyrrhizin* (from licorice), *frangulin* (from cascara bark), *jalapin* (from jalap and scammony-resin), *myronic acid* (from black mustard), *salicin* (from willow bark and leaves), *santonin* (from wormseed), *saponin* (from soap-bark, senega, sarsaparilla, etc.), and *strophanthin* (from strophanthus seed).

## CHAPTER XVIII

### ALKALOIDS AND PTOMAINES

**Alkaloids** are found in the leaves, stems, roots, barks, and seeds of various plants. The term "*Alkaloid*" means alkali-like; *i.e.*, alkaline or basic in reaction. They combine with acids to form salts. The volatile alkaloids have a disagreeable odor. Most of them are insoluble in water, but soluble in alcohol. The solid alkaloids are white, crystalline solids and have a strong, bitter taste. All alkaloids have a very energetic physiological action. Most are precipitated by tannic and picric acids, and give color reactions with oxidizing agents, such as nitric acid, potassium dichromate, ferric chloride, etc.

#### PILOCARPINE

Found in the leaves of the plant *Pilocarpus*. It is a colorless to yellow, syrupy liquid, soluble in alcohol, water, and chloroform. The hydrochloride and hydrobromide are usually employed.

The alkaloid and its salts are used in medicine as myotics, expectorants, and in hair tonics.

With fuming nitric acid it gives a green color.

#### NICOTINE

Found in the tobacco plant, from 2 to 8 per cent. occurs in the leaves. It is a colorless to yellowish, oily liquid, turning brown on exposure to the air, has a pungent, disagreeable odor (*old pipe*) and a burning taste. It is soluble in water.

It gives a violet color with hydrochloric acid.

#### ATROPINE

Found in the leaves and root of the plant *Atropa Belladonna*. It is a white, crystalline powder with a bitter taste and no odor. It is slightly soluble in water, but easily soluble in alcohol and chloroform. The sulphate and hydrobromide are usually employed. Atropine dilates the pupil.

With sulphuric acid, atropine yields a colorless solution, which, *upon prolonged contact* with potassium dichromate, yields a green solution. If this green solution is diluted with water and boiled, a pleasant odor, resembling that of roses and orange-flowers, is developed.

#### HYOSCYAMINE

Found with hyoscyne in *hyoscyamus* ("henbane"). It resembles atropine in physical, chemical, and physiological properties. The hydrobromide and sulphate are official.

#### COCAINE

Found in the leaves of the South American shrub, *Erythroxylon Coca*. It occurs as a white, crystalline powder, slightly soluble in water, but easily soluble in alcohol. Particles placed on the tongue cause numbness and loss of sense of taste. The hydrochloride is official and is usually employed.

The compound is a local anæsthetic.

#### QUININE

Found in *Cinchona* bark. It is a white, crystalline solid with an extremely bitter taste. It is almost insoluble in water, but dissolves in alcohol. The sulphate, bisulphate, hydrobromide, hydrochloride, and salicylate are the official salts.

The alkaloid and its salts are used as antiperiodics, antipyretics, antiseptics, and tonics.

A solution of quinine in diluted sulphuric acid displays a vivid, blue fluorescence.

#### CINCHONINE

Found in *Cinchona* bark. It is a white, crystalline solid having a bitter taste. It is insoluble in water, but easily soluble in alcohol. The sulphate is official.

It is used like quinine.

#### STRYCHNINE

Usually obtained from *Nux Vomica*. It is a white, crystalline powder having an extremely bitter taste. It is almost insoluble



in water, but dissolves in alcohol and chloroform. The sulphate and nitrate are official salts.

Strychnine is a bitter tonic, excito-motor stimulant, and stomachic.

Potassium dichromate added to a solution of strychnine in sulphuric acid gives a deep blue color, which rapidly changes to violet, then to cherry-red, and finally fades to yellow.

### MORPHINE

A white, crystalline solid, odorless, and having a bitter taste. Soluble in 300 parts of alcohol, 5000 parts of water, and 100 parts of lime water. The acetate, hydrochloride, and sulphate are official.

Opium is a concrete, milky *exudation* obtained from the unripe capsules of the poppy. It contains a large number of alkaloids, the most important being **morphine** and **codeine**. It is a constituent of "**Paregoric**" and "**Laudanum**."

Morphine is a hypnotic, sedative, and narcotic.

Nitric acid first reddens morphine and then turns it yellow.

### CODEINE

White prisms or a crystalline powder, odorless, and having a faintly bitter taste. Soluble in 120 parts of water and 1.6 parts of alcohol. The phosphate and sulphate are official.

Its action is similar to morphine.

### APOMORPHINE HYDROCHLORIDE

This is a salt of an artificial alkaloid obtained from morphine, and comes in the form of a grayish-white, crystalline solid, which turns green on exposure, has a faintly bitter taste, and is soluble in water and alcohol.

It is an emetic.

### DIONIN

"*Ethylmorphine Hydrochloride*"

This compound is the hydrochloride of the ethyl ester of morphine. It comes as a white powder, having a slightly bitter taste and no odor. It is soluble in water and alcohol.

It is used as an ocular lymphagogue.

**HEROIN**

*“ Diacetyl-morphine ”*

This is obtained by heating morphine and acetyl chloride. It occurs as a white powder, having a bitter taste. It is almost insoluble in water, but readily dissolves in hot alcohol. The hydrochloride is usually employed.

It is a cough-sedative and antispasmodic

**PHYSOSTIGMINE**

*“ Eserine ”*

Found in the seeds of the Calabar bean. It occurs as an odorless, tasteless, white powder, which turns pink upon exposure. It is soluble in water and alcohol. The sulphate and salicylate are official.

It is used to break up adhesions of the iris.

**ACONITINE**

Found in the tuberous root of the plant Aconite or “ Monks-hood.” It occurs as a white, crystalline powder with a feebly bitter taste. It is soluble in alcohol, chloroform, and ether, and is *intensely poisonous*. Highly-diluted solutions produce a tingling sensation on the tongue, but solutions should not be tasted.

**VERATRINE**

This is officially defined as an alkaloid or mixture of alkaloids obtained from the seeds of the plant *Asagæa officinalis*. It occurs as a white, amorphous, or crystalline powder, having a disagreeable, acid taste. It is slightly soluble in water, but readily soluble in alcohol and chloroform.

It is used as a local anæsthetic over neuralgic nerves.

With sulphuric acid it gives a yellow color, turning scarlet and, finally, violet-red.

**HYDRASTINE**

Found in the roots of Hydrastis or “ Golden Seal.” It comes in the form of white prisms, soluble in alcohol, ether, and chloroform, and slightly soluble in water.

It is used to arrest hemorrhage from the uterus and to decrease profuse menstruation.

**CONIINE**

Found in the plant Conium or "Poison hemlock." It occurs as a colorless, oily liquid, having a mossy odor. It is soluble in alcohol, ether, and chloroform. The hydrobromide is usually employed.

**SPARTINE**

This alkaloid is found in the plant Scopolius or "Broom." It is a colorless, oily liquid, turning brown on exposure to air and light. It has an aniline-like odor, and is soluble in water, alcohol, chloroform, and ether. The salts, chiefly the sulphate, are used.

It is used as a diuretic.

**CAFFEINE**

Found in tea, coffee, and parts of other plants. It occurs as soft, colorless, flexible, long, silky crystals, having no odor, but a bitter taste. It is soluble in water, alcohol, and chloroform. The citrate is official.

It is a diuretic and stimulant.

**PTOMAINES**, sometimes called "*Animal alkaloids*," are the products of putrefaction of organic substances, especially animal matter. This decomposition or putrefaction is brought about by bacterial action, so we might say that ptomaines are the products of the action of bacteria on organic matter. In many ways they resemble alkaloids—so much so that it is difficult for the toxicologist to identify alkaloids in the presence of ptomaines. Ptomaines are *poisonous* and *non-poisonous*.

**ISOAMYLAMINE**

A colorless, alkaline liquid which is found in putrefying yeast and cod-liver oil. It is strongly poisonous, producing rigor, convulsions, and death.

**CADAVERINE**

A syrupy liquid of unpleasant odor, found in decomposing animal tissue. It is not very poisonous, but produces severe inflammation.

**NEURINE**

Frequently occurs in decomposing meat. It is exceedingly poisonous even in small doses. Atropine readily counteracts it.

**TETANINE**

This compound may be obtained from the limb of a tetanus patient. It produces symptoms very similar to those of tetanus.

**TYROTOXICON**

This is a very highly poisonous ptomaine formed at times in milk, ice-cream, cheese, etc.



**PART IV**  
**PHYSIOLOGICAL CHEMISTRY**



## CHAPTER XIX

### PROTEINS

**Proteins** are highly complex compounds of carbon, hydrogen, oxygen, nitrogen, and sulphur; a few contain iron and phosphorus. They occur as viscous solids or in solution in most parts of the body. They are an essential constituent of all normal diets, and have their sources as foods in both animal and vegetable substances.

The analyses of a number of proteins give the following for an average percentage composition:

Carbon.....	52.00 per cent.
Hydrogen.....	7.00 per cent.
Nitrogen.....	16.00 per cent.
Oxygen.....	23.00 per cent.
Sulphur.....	2.00 per cent.

#### CLASSIFICATION OF PROTEINS

**I. Simple proteins:** as albumins, globulins, histones, etc.

**II. Conjugated proteins:** as nucleoproteins, phosphoproteins, hæmoglobins, etc.

**III. Derived proteins:** as metaproteins, peptones, proteoses, peptids, etc.

The white of egg is a familiar example of protein matter, being composed largely of albumin, with a small amount of globulin.

**Tests for Proteins.**—Use a solution of about 10 parts of a 2 per cent. sodium chloride solution (aqueous) and 1 part of the white of egg.

**1. Heat Test.**—To 5 cubic centimetres of protein solution add a few drops of acetic acid and heat. The protein is coagulated as a white, gelatinous mass.

**2. Heller's Test.**—To 5 cubic centimetres of protein solution add a few drops of nitric acid. The protein is coagulated as with heat.



3. **Xanthoproteic Test.**—(Use *dry* protein.) Heat a small quantity of the protein with concentrated nitric acid. The protein turns yellow. Cool and neutralize with ammonium hydroxide. The color changes to orange.

4. **Biuret Test.**—Boil a small portion of protein solution with 5 cubic centimetres of a 10 per cent. solution of sodium hydroxide and cool. Add one or two drops of a dilute solution of copper sulphate. A violet to pink coloration will result. Sometimes it is necessary to apply heat after adding the copper sulphate solution to obtain the color.

5. **Lieberman's Test.**—To some *dry* protein add 5 cubic centimetres of concentrated hydrochloric acid and warm. A deep blue to violet color develops. Upon standing the color disappears.

## CHAPTER XX

### FOODSTUFFS

THE following is the classification of foodstuffs generally used:

1. **Proteins:** as lean meat, white of egg, etc.
2. **Carbohydrates:** as sugar, starch, etc.
3. **Fats:** as butter, lard, fat meat, etc.
4. **Water.**
5. **Inorganic salts:** as common salt, calcium phosphate, etc.

The *proteins* are used largely for their nitrogen, the *carbohydrates* for their carbon, the *fats* as heat producers, the *water* as a carrier and heat regulator, the *inorganic salts* for the construction of bones, and liberation of hydrochloric acid in the gastric juice. A well-balanced diet must contain a definite ratio, or approximately so, of each of the above classes of food, according to climate, age, and the amount of work done by the individual. A large number of suggested ratios are in existence. Voit suggests the following for twenty-four hours:

Protein.....	118 grammes, or	3.9 ounces
Fat.....	100 grammes, or	3.3 ounces
Carbohydrates.....	333 grammes, or	11.1 ounces

This, as well as similar tables, is based on experiments which show the amount of food actually assimilated and cast off as waste products. The nutritive value of food depends largely on the amount of readily digestible carbon and nitrogen it contains. The oxygen used in nutrition is oxidized into carbon dioxide and exhaled by the lungs. A man doing ordinary work will give off daily 250 to 280 grammes of carbon from the lungs in the form of carbon dioxide. The amount increases with an increase of labor. The nitrogen used in nutrition is broken up to form urea, mainly, and is eliminated by the kidneys in the urine. A man on normal diet eliminates 15 to 18 grammes of nitrogen daily in the form of urea. An increase in labor produces little or no change in the amount of

urea excreted. By comparing the ratio of carbon and nitrogen used and eliminated we have carbon 250 or 280 grammes is to nitrogen 15 or 18 grammes; or about 16 parts of carbon to 1 part of nitrogen.

All foods that contain nitrogen usually contain available carbon also, so in selecting an ideal diet it is essential to know the available nutritive constituents of the food. G. N. Stewart recommends the following as a typical daily diet for a man doing normal work:

Foodstuff	Quantity		Grammes of					
			Nitrogen	Carbon	Proteins	Carbohy- drates	Fats	Salts
Lean meat....	250	9	8	33	55	0	8.5	4.0
Bread.....	500	18	6	112	40	245	7.5	6.5
Milk.....	500	$\frac{1}{2}$ pint	3	35	20	25	20.0	3.5
Butter.....	30	1	0	20	0	0	27.0	0.5
Fat with meat	30	1	0	22	0	0	30.0	0.0
Potatoes.....	450	16	1.5	47	10	95	0.0	4.5
Oatmeal.....	75	3	1.7	30	10	48	4.0	2.0

### MILK

Milk is often referred to as the "perfect food." This depends on the kind of milk and the individual for whom it is intended. For adults milk would have to be taken in very large quantities, and, besides, it is relatively too rich in protein and fat, and contains too little iron. The following comparison from Bunge may be valuable:

	Woman's milk	Cow's milk
	<i>Per cent.</i>	<i>Per cent.</i>
Proteins (chiefly caseinogen) ..	1.7	3.5
Butter (fat) .....	3.4	3.7
Lactose (sugar).....	6.2	4.9
Salts.....	0.2	0.7

It may be seen from this that cow's milk is too rich in protein and too poor in lactose for infants. This fault in cow's milk may be partially corrected by diluting it and adding sugar (lactose).

### MEAT

Meat (lean) is the most concentrated and most easily assimilated of all nitrogenous foods. There is always a small amount of fat in all lean meat. The arrangement of the fat in the cell tissue causes some meat to be more easily digested than others. Lean pork is more difficult to digest than beef because the fat is so distributed in the pork as to hinder the activity of the gastric and pancreatic juices.

### BREAD

Bread is a representative type of carbohydrate food. It is composed of from 50 to 75 per cent. of starch.

### THE COOKING OF FOODSTUFFS

The ideas of cooking foods have developed with the development of nations and individuals. Much cooking is unscientific and at times is largely a matter of personal taste and cultivation.

#### *Objects of Cooking*

1. *To Destroy Bacteria.*—Many raw foods are infected with harmful bacteria which may be destroyed by thorough cooking.
2. *To Render Starch Digestible.*—Raw starch is surrounded by an insoluble capsule, which is not penetrated by digestive juices. Thorough cooking breaks down the walls of these capsules and allows the juices to digest the starch. †
3. *To Render Meat Digestible.*—The meat cells are joined together by an insoluble connective tissue called "collagen." Thorough cooking changes the insoluble collagen to soluble gelatine. By thus loosening the connective tissue, the muscular part of the meat, the important food element, is rendered accessible to the digestive juices.

### GREEN VEGETABLES

The nutritive value of green vegetables is very small. They are taken rather as a palatable adjunct than as food. The percentage of proteins in cabbage, turnips, etc., is from 1 to 2 per cent.,

and of carbohydrates, 2 to 4 per cent. Very large quantities have to be eaten to get much material of real food value. They, however, contain valuable mineral salts and act beneficially as diluents.

## TABLE OF CALORIFIC VALUES

(After Frankland and Jürgensen)

*Calorific Value of 100 Grammes in Calories*

Apples.....	66.00	Egg, White of.....	67.10
Arrowroot.....	391.20	Egg, Yelk of.....	342.30
Asparagus.....	18.50	Flour.....	393.60
Bean-soup.....	193.00	Flounder.....	100.60
Beef, Raw.....	118.95	Macaroni.....	352.60
Beef, Boiled.....	209.00	Mackerel.....	178.90
Beef, Broiled.....	213.60	Milk.....	66.20
Beef, Lean.....	156.70	Milk, Skim.....	39.61
Beef-fat.....	906.90	Oatmeal.....	400.40
Bread-crumb.....	223.10	Omelet.....	236.70
Bread, Wheat.....	281.00	Pea-meal.....	393.60
Bread, Wheat, Toasted.....	258.80	Peas, Green.....	318.00
Butter.....	814.00	Pigeon.....	99.70
Buttermilk.....	41.56	Potatoes.....	101.30
Cabbage.....	43.40	Rice, Ground.....	318.30
Cakes.....	374.00	Salmon.....	133.30
Carp.....	93.00	Sugar, Cane.....	334.80
Carrots.....	41.00	Trout.....	106.40
Chicken-breast.....	106.40	Veal Cutlets, Raw.....	142.45
Cheese, Cheshire.....	464.70	Veal Cutlets, Broiled.....	230.50
Cod-liver Oil.....	910.70	Whiting.....	90.40
Cream.....	214.70	Zwieback.....	357.80
Egg, Hard-boiled.....	238.30		

## CHAPTER XXI

### DIGESTION

**DIGESTION** is the process of preparing the food for assimilation into the body tissue. It is both mechanical and chemical. In the mechanical process the food is disintegrated and propelled along the alimentary canal. Most of the food consumed has to undergo chemical change before assimilation takes place. These chemical changes are brought about by ferments or enzymes, for the most part, each ferment bringing about a specific chemical reaction.

For convenience of study we classify digestion as:

**I. Salivary Digestion.**—Salivary digestion takes place chiefly in the mouth. Here the mechanical digestion is greater than the chemical. Grinding the food and thoroughly mixing with the *saliva* are important. The *saliva* is secreted by glands leading into the mouth. It is a frothy, odorless, tasteless liquid, usually alkaline in reaction. The quantity secreted in a day varies from 600 to 1500 cubic centimetres. Its chemical composition is given on page 166.

**Ptyalin** is the active enzyme of saliva. Its function is to convert starch to dextrose. Since this is the first action and the period of time is short, only a part of the starch undergoes this change.

**II. Gastric Digestion.**—The food, after mastication, passes from the oesophagus into the stomach. The mechanical process here is one of kneading the mass and mixing it with the *gastric juice*. The *gastric juice* is a colorless liquid, having a sour taste and an acid reaction, due to the presence of hydrochloric acid. Its composition is as follows:

	Per cent.
Water.....	99.26
Pepsin.....	0.30
Hydrochloric acid (free).....	0.22
Salts.....	0.22

The active enzymes of gastric juice are **pepsin** and **rennin**. Proteins are acted upon by pepsin, which changes them to *peptones*.

Rennin curdles milk. The hydrochloric acid makes the food acid in reaction and also slightly changes the starch into dextrose.

**III. Intestinal Digestion.**—Intestinal digestion is rather complex, several different secreted fluids being active: (a) *pancreatic juice*, (b) *bile*, (c) *succus entericus* or *intestinal juice*.

*Pancreatic juice* varies too greatly in composition to give its analysis. It is a clear, thick, strongly alkaline fluid, containing about 10 per cent. of solid constituents. Its alkalinity is due chiefly to sodium carbonate. Among its important constituents are: (a) **amyllopsin**, which converts starch to dextrose; (b) **trypsin**, which converts proteins to peptones; (c) **steapsin**, which changes the fats into acids and glycerin; (d) a **milk-curdling enzyme** which has not been named.

*Bile* is a light-yellow to greenish-blue liquid, having a bitter taste and an alkaline reaction. It is highly complex in composition. It contains the "bile salts" sodium glycocholate and sodium taurocholate, which precipitate peptones in the small intestine, thus aiding in their absorption. Bile contains two normal pigments: bilirubin, reddish-yellow, and biliverdin, green. The bile has but little chemical action on the food. It exerts an accentuating influence on the enzymes or ferments of the pancreatic juice, whose actions are doubled or even trebled.

*Succus entericus* is the clear, viscid, light-yellow, opalescent, strongly alkaline secretion of the lower intestines, and contains enzymes which are active to some degree on all classes of food. Its alkalinity aids in neutralizing the acid from the stomach, although it serves as an excellent medium for bacterial action.

**Absorption** of the digested food takes place principally in the large and small intestines. Just how this absorption takes place is not definitely agreed upon.

## CHAPTER XXII

### THE CHEMICAL COMPOSITION OF THE HUMAN BODY

TWENTY-ONE elements are normally found in the human body, and seventeen of these are constantly present. The following table gives the percentages of the elements:

Element	Percentage
Oxygen.....	72.00
Carbon.....	13.50
Hydrogen.....	9.00
Nitrogen.....	2.50
Calcium.....	1.30
Phosphorus.....	1.15
Sulphur.....	0.143
Sodium.....	0.10
Fluorine.....	0.084
Chlorine.....	0.084
Potassium.....	0.025
Magnesium.....	0.0125
Iron.....	0.01
Silicon.....	0.002
Manganese.....	0.0005
Iodine.....	trace
Arsenic.....	trace
Bromine.....	trace
Aluminium.....	trace
Lead.....	trace
Copper.....	trace

**Note.**—The first seventeen are those constantly present.

The foregoing elements occur chiefly in combination, but **oxygen**, **nitrogen**, and **hydrogen** are also found in the free state, the oxygen and nitrogen being inhaled and swallowed, and the hydrogen being a product of putrefaction. Appreciable traces of **iodine** are found in the thyroid. Traces of **manganese**, **arsenic**, **bromine**, **aluminium**, **lead** and **copper** are occasionally found in the liver, which organ acts as a protector from poisons for the rest of the organism. **Arsenic** is found in the thyroid, thymus, brain,



hair, and skin. **Iron** is the coloring matter of the blood, bile, hair, and skin pigments. It is present in organic combination as ferratin and heparin in the liver.

The ashes left after cremation ( $2500^{\circ}$  C. for about 60 minutes) weigh from 4 to 6 pounds. The final products of decomposition of the body after death are simple compounds, such as water ( $\text{H}_2\text{O}$ ), carbon dioxide ( $\text{CO}_2$ ), hydrogen sulphide ( $\text{H}_2\text{S}$ ), ammonia ( $\text{NH}_3$ ), metallic chlorides, phosphates, and sulphates. Cadaveric alkaloids or ptomaines are intermediate products.

The solid constituents of the body consist of about 17 per cent. inorganic and 83 per cent. organic matter.

**Water** ( $\text{H}_2\text{O}$ ) is the most abundant of the compounds found in the body, constituting about 67.7 per cent. by weight. It acts as the solvent for absorption, secretion, and excretion, makes the tissues soft and elastic, and regulates body heat by evaporation.

**Hydrogen dioxide** ( $\text{H}_2\text{O}_2$ ) has been found in sweat and other body fluids. It is most likely formed by cell-decomposition, in which nascent hydrogen is liberated and unites with oxygen, producing hydrogen dioxide. The compound readily breaks down into water and nascent oxygen.

**Carbon dioxide** ( $\text{CO}_2$ ) is formed in living cells by oxidation, and in the alimentary tract as a product of fermentation. It exists in the blood in combination with sodium.

**Hydrogen sulphide** ( $\text{H}_2\text{S}$ ) is found in the intestines as a product of the putrefaction of proteins. It is also found in abscess cavities.

**Ammonia** ( $\text{NH}_3$ ) is formed in the tissues by the union of hydrogen and nitrogen. It combines with carbon dioxide to form ammonium carbamate ( $\text{NH}_4\text{NH}_2\text{CO}_2$ ), which is decomposed into **urea** ( $(\text{NH}_2)_2\text{CO}$ ) and water ( $\text{H}_2\text{O}$ ) in the liver.

**Methane** ( $\text{CH}_4$ ), the only hydrocarbon found in the body, occurs as a product of the fermentation of cellulose, the putrefaction of proteins, and the decomposition of acetates. It is one of the gases that give rise to flatulence and colic.

Of the **chlorides**, **sodium chloride** ( $\text{NaCl}$ ) is present in all the fluids of the body and in all tissues except enamel, **potassium**

**chloride** (KCl) occurs in the blood-corpuscles and muscles principally, and **calcium chloride** ( $\text{CaCl}_2$ ) is one of the necessary constituents of the blood.

**Calcium fluoride** ( $\text{CaF}_2$ ) is found chiefly in the teeth and bones.

**Sodium, potassium, calcium and magnesium phosphates** are found in almost every fluid and tissue. The acidity of the urine is largely due to the presence of monosodium-dihydrogen orthophosphate ( $\text{NaH}_2\text{PO}_4$ ), while the alkalinity of the blood is partly due to disodium-monohydrogen orthophosphate ( $\text{Na}_2\text{HPO}_4$ ). **Ferric phosphate** ( $\text{FePO}_4$ ) is a constituent of the gastric and intestinal juices, the pigment of the epithelium and hair, and of the bile.

**Sodium and potassium carbonates** ( $\text{Na}_2\text{CO}_3$  and  $\text{K}_2\text{CO}_3$ ) are found in the blood, which they assist in making alkaline. They readily react with carbon dioxide, forming the bicarbonates.

**Calcium carbonate** ( $\text{CaCO}_3$ ) is present in the teeth and bones, and forms the otoliths of the internal ear.

**Ammonium carbonate** ( $(\text{NH}_4)_2\text{CO}_3$ ) is found only in traces in the blood.

Small quantities of **sodium, potassium and calcium sulphates** ( $\text{Na}_2\text{SO}_4$ ,  $\text{K}_2\text{SO}_4$ , and  $\text{CaSO}_4$ ) are found in most parts of the body.

**Silica** ( $\text{SiO}_2$ ) is present in very small amounts in the blood, urine, bones, and hair.

**Dextrose** ( $\text{C}_6\text{H}_{12}\text{O}_6$ ) is the principal sugar of the blood and the muscles. It is derived mainly from starch and cane-sugar.

**Lactose** ( $\text{C}_{12}\text{H}_{22}\text{O}_{11}$ ) is the principal ingredient of woman's milk. When the milk-flow is obstructed, it may be found in the urine and blood.

**Glycogen**, or "liver-starch" ( $(\text{C}_6\text{H}_{10}\text{O}_5)_n$ ), is present in the muscles and liver, as well as in tumors. Muscular work, hunger, and cold draw upon the supply of this compound that is stored up.

**Inosit**, or "muscle-sugar" ( $\text{C}_6\text{H}_{12}\text{O}_6$ ), is present in the muscles and viscera.

The **fat** of the body is in fluid condition, occurring as an emulsion in the circulating fluids, as drops in special (*adipose*) cells, and in the interior of tissue cells. It is the product of the storage of food fats, as well as a derivative of carbohydrates and proteins.

The wrinkles of old age are caused by the loss of subcutaneous fat.

**Lecithin** ( $C_{44}H_{90}NPO_9$ ) is a waxy, phosphorized fat found in the brain and nerves, as well as in every living cell. **Protagon** is a compound present in the brain, and contains lecithin and **cerebrin** ( $C_{17}H_{33}NO_3$ ), a glucoside.

**Formic acid** ( $HCOOH$ ) is found in sweat. Its salts (*formates*) are found in the blood and urine.

**Acetic acid** ( $CH_3COOH$ ) is frequently found in the fæces. In certain diseases, like diabetes, it is found in the blood, urine, and sweat.

**Diacetic acid** ( $CH_3CH_2COCOCH_3$ ) and **beta-oxybutyric acid** ( $CH_3CH(OH)CH_2COOH$ ) are probably products of fat-metabolism, and are increased in diabetes and starvation, neutralizing the blood and causing an increase of ammonia in the urine.

**Propionic acid** ( $C_2H_5COOH$ ) is found in the bile, sweat, and, at times, in the stomach.

**Butyric acid** ( $C_3H_7COOH$ ) is found in fæces, and in the stomach contents in hypochlorhydria. This acid is frequently the cause of bad taste in the mouth.

**Oxalic acid** ( $(COOH)_2$ ) is a product of the metabolism of nucleins and gelatines.

**Isovaleric acid** ( $C_4H_9COOH$ ) is found in the sweat of feet, and, in certain diseases, in the urine. It is foul-smelling.

**Capric or rutylic acid** ( $CH_3(CH_2)_8COOH$ ) and **caprylic acid** ( $CH_3(CH_2)_6COOH$ ) are found in milk-fat and perspiration.

**Stearic acid** ( $C_{17}H_{35}COOH$ ), **oleic acid** ( $C_{17}H_{33}COOH$ ), and **palmitic acid** ( $C_{16}H_{31}COOH$ ) are found in milk-fat, adipose tissue, and bile.

**Lactic acid** ( $C_3H_5OHCOOH$ ) is frequently found in the fæces of infants. It is a product of fermented milk.

**Sarcosine** ( $CH_3OH.CH_2.NH_2$ ) is found in the blood, blood-glands, and muscles. When in excess it produces fatigue.

**Uric acid** ( $C_5H_4N_4O_3$ ) is excreted in the urine in daily amounts (*normally*) of from 0.4 to 0.8 gramme. Coffee, tea, cocoa, meat extracts, and the flesh of young animals increase the amount of uric acid. When the alkalinity of the blood is reduced, uric acid

is thrown out of solution and collects in the spleen, joints, and liver, the more acid tissues. This would take place normally during the winter, when meat is eaten freely. In the spring, when sweating is more profuse, the alkalinity increasing because of the excretion of fatty acids, the deposits of uric acid in the parts mentioned are swept out in the blood current, causing irritation of the nerves and producing what is popularly known as "that tired feeling." Uric acid is normally destroyed by oxidation to **urea** ( $(\text{NH}_2)_2\text{CO}$ ) in the kidneys, liver, muscles, spleen, and blood. In gout the underlying factor is deficient oxidation of this acid. The pure acid comes in the form of white, tasteless, odorless crystals, soluble in 1900 parts of boiling and 15,000 parts of cold water, and almost insoluble in alcohol and ether. This latter property (comparative insolubility) is the cause of its separating out in solid state in the bladder and tissues. The acid is also found in the excrements of birds, mollusks, insects, and serpents, and in Peruvian guano.

**Fellic acid** ( $\text{C}_{23}\text{H}_{38}\text{O}_4$ ), **cholic acid** ( $\text{C}_{24}\text{H}_{40}\text{O}_5$ ), and **choleic acid** ( $\text{C}_{24}\text{H}_{40}\text{O}_2$ ) are protein derivatives, and have the power of forming salts, which dissolve the more insoluble fatty acids and soaps.

**Acetone** ( $(\text{CH}_3)_2\text{CO}$ ) is found in the blood and urine. In certain diseases, such as diabetes, the amount of this compound is increased.

**Phenol** ( $\text{C}_6\text{H}_5\text{OH}$ ), **indol** ( $\text{C}_8\text{H}_7\text{N}$ ), and **skatol** ( $\text{C}_8\text{H}_5\text{CH}_3\text{NH}$ ) are formed in the intestines by the putrefaction of proteins.

**Creatine**, or methylguanidine acid ( $\text{HNCNH}_2\text{NCH}_2\text{CH}_2\text{COOH}$ ), is excreted in the urine as **creatinine**; *i.e.*, creatine minus water:  $\text{C}_4\text{H}_9\text{N}_3\text{O}_2$ . It is a product of compound proteins.

**Tyrosine** ( $\text{C}_9\text{H}_9\text{OHC}_2\text{H}_3(\text{NH}_2)\text{COOH}$ ) and **leucine** (amido-caproic acid) ( $\text{C}_6\text{H}_{10}\text{NH}_2\text{COOH}$ ) are products of tryptic digestion of peptones. They are oxidized to urea in the liver.

**Glycocoll**, or amido-acetic acid ( $\text{CH}_2\text{NH}_2\text{COOH}$ ), is another normal decomposition product of proteins. It exists in the bile as **glycocholic acid** ( $\text{C}_{26}\text{H}_{43}\text{NO}_6$ ) and in the urine with benzoic acid and hippuric acid ( $\text{C}_9\text{H}_9\text{NO}_3$ ).

**Urea** ( $(\text{NH}_2)_2\text{CO}$ ) normally occurs in the blood, muscles, and viscera (0.08 to 0.16 per cent.), and in the kidneys (0.67 per cent.).

Its principal site of origin is in the liver, where it is produced by the decomposition of ammonium carbamate ( $\text{NH}_4\text{NH}_2\text{CO}_2 - \text{H}_2\text{O} = (\text{NH}_2)_2\text{CO}$ ), leucine, and glycocoll. It is the chief product of nitrogenous metabolism.

**Choline**, or trimethyl-oxyethyl-ammonhydroxide ( $\text{NC}_2\text{H}_4\text{OH}(\text{CH}_3)_3\text{OH}$ ), and **neurine** (choline minus water) are produced in the intestines by the action of bacteria on proteins.

**Taurine** ( $\text{NH}_2\text{C}_2\text{H}_4\text{SO}_3\text{H}$ ) is present in the muscles, spleen, bile, and suprarenal capsule as sodium taurocholate.

**Cholesterin** ( $\text{C}_{27}\text{H}_{45}\text{OH}$ ) is a product of nerve metabolism, as well as a product of the hydrolysis of carbohydrates by the gall-bladder and bile-passages epithelium. If more is formed than can be dissolved by the bile-salts, it crystallizes out, forming gall-stones.

**Bilirubin** ( $\text{C}_{42}\text{H}_{62}\text{N}_2\text{O}_5$ ) and **biliverdin** ( $\text{C}_{42}\text{H}_{58}\text{N}_2\text{O}_4$ ) are the two normal bile-pigments.

**Melanins** are brown and black sulphur-containing pigments found in the hair, the skin of negroes, and in some forms of tumors.

## EXPERIMENTS

### I. Tests for the More Common Metals

(22) **Test for Potassium.** (Flame Test.)—Clean a platinum wire by heating in the Bunsen flame until no color is imparted to the flame. Then dip the wire, avoiding contact with any other material or the fingers, into a solution of a potassium salt and heat again. A violet color will be imparted to the flame.

(23) **Test for Sodium.** (Flame Test.)—Repeat as above, using a solution of a sodium salt. An intense yellow color will be imparted to the flame.

(24) **To Identify Potassium and Sodium when Occurring Together.**—Sodium, because of the intense yellow color it imparts, will entirely cover the violet color that potassium imparts to the flame. Dip a clean wire in a solution containing a sodium and a potassium salt, hold in the flame, and examine the flame by placing a blue glass before the eyes. The blue glass will absorb the yellow rays and allow the passage of the violet only.

(25) **Test for Lithium.** (Flame Test.)—Dip a clean wire in a solution of a lithium salt and hold in the flame. A carmine color will be imparted to the flame.

(26) **Test for Ammonium.**—(a) Heat a solution of an ammonium salt, with enough potassium or sodium hydroxide to make it alkaline, in a test-tube, keeping the thumb over the mouth of the tube. Upon removing the thumb, the odor of ammonia gas can be easily perceived; or moistened red litmus paper held over the mouth of the tube (avoiding contact with the sides and contents) will become blue.

(b) *Nessler's Test for Ammonium*.—An aqueous solution of red iodide of mercury ( $\text{HgI}_2$ ) made alkaline with potassium hydroxide, when added to a colorless solution of an ammonium salt, gives a yellow color or precipitate.

(27) *Test for Calcium*.—(a) *Flame Test*.—Calcium salts impart a yellow-red color to the colorless flame of the Bunsen burner.

(b) *Precipitation Test*.—Add some solution of ammonium oxalate  $((\text{NH}_4)_2\text{C}_2\text{O}_4)$  to a solution of a calcium salt. A white, crystalline precipitate of calcium oxalate ( $\text{CaC}_2\text{O}_4$ ) will appear. The flame test may be carried out on the precipitate.

(28) *Test for Magnesium*.—To a solution of a magnesium salt add enough ammonium hydroxide ( $\text{NH}_4\text{OH}$ ) to make alkaline, then ammonium chloride ( $\text{NH}_4\text{Cl}$ ) solution until clear, and, finally, some solution of sodium phosphate ( $\text{Na}_2\text{HPO}_4$ ). A white, crystalline precipitate of magnesium ammonium phosphate ( $\text{MgNH}_4\text{PO}_4$ ) will appear.

(29) *Test for Iron*.—Iron salts may be *ferrous* or *ferric*. **Ferric** salts give a blood-red color with potassium thiocyanate ( $\text{KSCN}$ ). **Ferrous** salts (if free from ferric) give no color.

*The Test*.—If the salt under examination is a ferrous compound, add to its solution a few drops of nitric acid ( $\text{HNO}_3$ ), and boil so as to oxidize it to the ferric condition. Add some solution of potassium thiocyanate and note the formation of a blood-red color.

(30) *Test for Manganese*.—To some solution of a manganese salt (use the sulphate) add a large excess of concentrated nitric acid ( $\text{HNO}_3$ ), heat nearly to boiling, and add some "red lead" ( $\text{Pb}_3\text{O}_4$ ). Allow the mixture to stand. A purple-colored solution will result, due to the formation of permanganic acid ( $\text{HMnO}_4$ ).

## II. Tests for the More Common Acids

(31) *Test for Hydrochloric Acid and Soluble Chlorides*.—Make the solution acid with diluted nitric acid ( $\text{HNO}_3$ ), and add some solution of silver nitrate ( $\text{AgNO}_3$ ). A white, curdy precipitate, blackening upon exposure to light, will form. The white precipitate is silver chloride ( $\text{AgCl}$ ).

(32) *Test for Sulphuric Acid and Soluble Sulphates*.—Make the solution acid with diluted hydrochloric acid ( $\text{HCl}$ ), and add some barium chloride ( $\text{BaCl}_2$ ) solution. A heavy, white, crystalline precipitate of barium sulphate ( $\text{BaSO}_4$ ) will appear.

(33) *Test for Phosphoric Acid and Soluble Phosphates*.—Add some solution of ammonium molybdate  $((\text{NH}_4)_2\text{MoO}_4)$ , and warm. A yellow, crystalline precipitate will appear. (Arsenic and silicic acid interfere with this reaction.)

(34) *Test for Carbonic Acid and Carbonates*.—Add to the solution or the solid substance diluted hydrochloric acid ( $\text{HCl}$ ). A colorless, odorless gas is given off, which is carbon dioxide ( $\text{CO}_2$ ). If the gas is passed into some clear lime water ( $\text{Ca}(\text{OH})_2$ ), it will become turbid, due to the formation of calcium carbonate ( $\text{CaCO}_3$ ).

(35) *Test for Hydrosulphuric Acid and Sulphides*.—Add to the substance some diluted sulphuric acid ( $\text{H}_2\text{SO}_4$ ). A gas, having a strong, disagreeable odor, and which will blacken paper moistened with a solution of lead acetate ( $\text{Pb}(\text{C}_2\text{H}_3\text{O}_2)_2$ ), is liberated. The gas is hydrogen sulphide ( $\text{H}_2\text{S}$ ).

(36) *Test for Nitric Acid and Soluble Nitrates*.—Add some solution of ferrous sulphate ( $\text{FeSO}_4$ ) to the nitrate solution, and then pour in some concentrated sulphuric acid ( $\text{H}_2\text{SO}_4$ ) so as to form a separate layer. (Pour the acid slowly and carefully down the side of the tube.) A brown zone or ring will be formed at the junction of the two layers of liquid.

(37) **Test for Oxalic Acid and Soluble Oxalates.**—Add some solution of calcium chloride ( $\text{CaCl}_2$ ) to the oxalate solution. A white, crystalline precipitate of calcium oxalate ( $\text{CaC}_2\text{O}_4$ ) will be formed. This precipitate is soluble in diluted hydrochloric acid ( $\text{HCl}$ ), but is insoluble in acetic acid ( $\text{CH}_3\text{COOH}$ ).

(38) **Test for Hydriodic Acid and Soluble Iodides.**—Make the solution of the iodide acid with hydrochloric acid ( $\text{HCl}$ ), add some chloroform ( $\text{CHCl}_3$ ), and then add chlorine water, drop by drop, and shake. The chloroformic layer will settle to the bottom of the tube as a violet layer, the color being due to the liberated iodine.

(39) **Test for Hydrobromic Acid and Soluble Bromides.**—Make this test in the same manner as for hydriodic acid. In this case the chloroformic layer will be reddish-yellow, due to the liberation of bromine.

(40) **Test for Boric Acid and Soluble Borates.**—Make the solution of the borate acid with concentrated sulphuric acid ( $\text{H}_2\text{SO}_4$ ), add some alcohol ( $\text{C}_2\text{H}_5\text{OH}$ ), and apply a flame to the liquid. The mixture will burn with a green flame.

#### COMPOSITION OF BONE

Water.....	50.00
Fat.....	15.75
Ossein.....	11.40
Bone earth or mineral.....	22.85

#### COMPOSITION OF BONE EARTH OR MINERAL

Tri-calcium phosphate ( $\text{Ca}_3(\text{PO}_4)_2$ ).....	85.80
Calcium carbonate ( $\text{CaCO}_3$ ).....	8.50
Calcium fluoride ( $\text{CaF}_2$ ).....	3.20
Magnesium phosphate ( $\text{Mg}_3(\text{PO}_4)_2$ ).....	1.50
Sodium chloride ( $\text{NaCl}$ ).....	1.00
Sodium carbonate ( $\text{Na}_2\text{CO}_3$ ).....	

The following experiments may be carried out on bone:

(41) **Test for Water.**—Heat some bone in a dry test-tube and notice if water vapor condenses on the sides of the tube and escapes from the mouth.

(42) **Test for Ammonia.**—Test the gases evolved from the heated bone with moistened red litmus paper. The paper will become blue, and the odor of ammonia gas will be recognized.

(43) **Oils and Tar.**—No chemical test will be used. Simply notice the odor, color, reaction, etc., of the material in the tube after the ammonia test is carried out.

(44) **Tests for Metals and Acids.**—Heat some pieces of bone in a dry test-tube until a black, solid mass is left ("bone black"). Place the black residue in a crucible and continue heating until the carbon is burned away and "bone ash" is left. Use this ash for the following tests:

I. Dissolve some of the bone ash in diluted nitric acid ( $\text{HNO}_3$ ). Use the resulting solution for the following:

II. Divide the acid solution obtained above (I) into four portions:

a. Test one portion for sodium by means of the flame test described above (23).

- b. To another portion add ammonium hydroxide ( $\text{NH}_4\text{OH}$ ) until alkaline, and then add acetic acid ( $\text{CH}_3\text{COOH}$ ) until acid in reaction. Now add some ammonium oxalate ( $(\text{NH}_4)_2\text{C}_2\text{O}_4$ ) solution in excess. Heat the mixture and filter. A white, crystalline precipitate proves the presence of calcium. The precipitate is calcium oxalate ( $\text{CaC}_2\text{O}_4$ ). Save the filtrate and cool.
- b<sup>1</sup>. To the cooled filtrate obtained above (b) add a few drops of ammonium oxalate solution to insure the precipitation of all the calcium. Then add some sodium phosphate ( $\text{Na}_2\text{HPO}_4$ ) solution and make alkaline with ammonium hydroxide ( $\text{NH}_4\text{OH}$ ). A fine, white, crystalline precipitate of magnesium ammonium phosphate ( $\text{MgNH}_4\text{PO}_4$ ) will appear, proving the presence of magnesium.
- c. Test a third portion of the acid solution for hydrochloric acid as described under "Tests for the More Common Acids" (31).
- d. Test a fourth portion for phosphoric acid as described above under the acid tests (33).

III. Test some of the bone ash for carbonic acid in the manner described above, (34).

(45) **Test for Sulphur.**—Fuse some pieces of bone with some sodium carbonate ( $\text{Na}_2\text{CO}_3$ ) and some sodium nitrate ( $\text{NaNO}_3$ ) in a test-tube. Then cool and add some distilled water to the mass; warm and filter if necessary. To the liquid add some diluted hydrochloric acid ( $\text{HCl}$ ) to make acid, and then some solution of barium chloride ( $\text{BaCl}_2$ ). A white, crystalline precipitate of barium sulphate ( $\text{BaSO}_4$ ) will appear and indicates sulphur.

(46) **Test for Fat.**—Shake a piece of bone with some ether ( $(\text{C}_2\text{H}_5)_2\text{O}$ ) in a test-tube; pour off the ethereal layer and allow it to evaporate in a dish. Heat the residue left over the open flame. A strong, pungent odor (of acrolein) indicates fat.

(47) **Test for Ossein.**—Place a rather long, narrow bone in some diluted hydrochloric acid ( $\text{HCl}$ ) (1 part of  $\text{HCl}$  to 20 of  $\text{H}_2\text{O}$ ), and allow the mixture of bone, acid, and water to stand a day or two. Remove the bone. It will be noticed that the shape and size of the bone are retained, but that it can be tied into a knot. The acid has dissolved out the inorganic salts, leaving the ossein, which is a mixture of collagen and elastin.

## SALIVA

Saliva is a mixture of secretions from the parotid, submaxillary, and sublingual glands. It is normally an opalescent, odorless, tasteless, frothy liquid, slightly alkaline to litmus, but acid to phenolphthalein, owing to carbon dioxide. It is acid (lactic) in the morning before breakfast, and sometimes after much talking. It may be constantly acid from oral fermentation, mercurial salivation, in rheumatism, diabetes, fevers, and indigestion. It is intensely alkaline in ulcerative stomatitis. It may be neutral in reaction. There is some mucus mixed with it. The specific gravity varies from 1.002 to 1.009.



## Composition

Water.....	994.00
Solids.....	6.00

When allowed to stand, a sediment collects in the bottom of the vessel. This sediment consists of epithelial cells, corpuscles, etc. An examination of the sediment of mixed saliva shows the following:

Epithelium and mucus .....	2.18
Fat.....	0.07
Mucin.....	1.45
Ammonium thiocyanate.....	0.01
Sodium chloride, potassium chloride, calcium phosphate	2.29

**To Collect Saliva.**—First wash out the mouth with water to remove foreign substances; then collect saliva. To increase the flow, a piece of clean rubber may be chewed. Carry out the following tests on the collected saliva:

## EXPERIMENTS

(48) Note the color, odor, appearance, sediment, reaction, specific gravity.

(49) **Test for Albumin.**—Heat some clear saliva (filter first if necessary). A turbidity or cloudiness at the upper part of the test-tube indicates albumin.

(50) **Test for Thiocyanates.**—Put some saliva into a test-tube, add a few drops of diluted hydrochloric acid (HCl), shake, and add a few drops of ferric chloride ( $\text{FeCl}_3$ ) solution. A blood-red color indicates thiocyanates. The color is due to  $\text{Fe}(\text{SCN})_3$ , ferric thiocyanate.

(51) **Test for Ptyalin (Starch Ferment).**—(I) Ptyalin may be precipitated from saliva by adding alcohol ( $\text{C}_2\text{H}_5\text{OH}$ ).

(II) Add some starch paste to some saliva and heat on a water-bath at a temperature of about  $40^\circ\text{C}$ . for several minutes. Make sure that the saliva is slightly alkaline. Divide the heated mixture into two parts and examine as follows:

a. Test *one* portion for starch by adding a little diluted solution of iodine. If any starch is present, a blue color will develop.

b. Test the *second* portion for dextrose, using "Fehling's test" as described on page 171.

(52) **Test for Carbonates.**—Shake some saliva with some clear lime water and filter the mixture. Add to the precipitate on the filter-paper some diluted hydrochloric acid (HCl). Note the effervescence, which indicates carbonates.

(53) **Test for Metals and Bases.**—Make some saliva alkaline with ammonium hydroxide ( $\text{NH}_4\text{OH}$ ), warm, filter, and dissolve the precipitate on the paper in diluted nitric acid ( $\text{HNO}_3$ ). Divide this acid solution into one small (%) and one large (%) portion.

a. Use the *smaller* portion for tests for potassium, sodium, sulphates, chlorides, and phosphates as described under "Tests for the More Common Metals" and "Tests for the More Common Acids," pages 162, 163, and 164.

b. Use the *larger* portion for tests for calcium and magnesium as described under "Bone."

(54) **Test for Uric Acid and Urates.**—Sometimes it is well to test for uric acid and urates. The "*Murexid Test*," described on page 171, is usually employed.

(55) **Test for Mercury.**—Collect an abundant supply of saliva, place it in a dish, add diluted hydrochloric acid (HCl), heat on a water-bath for some time, and then filter. Save both filtrate and insoluble residue.

*a. Residue.*—Transfer the residue to a beaker, add diluted hydrochloric acid (HCl) and heat to boiling, adding some crystals of potassium chlorate ( $\text{KClO}_3$ ). Heat again until the odor of chlorine disappears. Filter the mixture and add to the filtrate some stannous chloride ( $\text{SnCl}_2$ ) solution. A white precipitate ( $\text{HgCl}_2$ ), which becomes black upon the further addition of stannous chloride, indicates mercury.

*b. Filtrate.*—Place in the filtrate a piece of *clean*, bright copper foil, and allow to stand. Remove the foil after a time. If a grayish deposit has formed on it, mercury is indicated.

### BLOOD

The blood is essentially a yellow solution called *plasma*, with suspended bodies or platelets called *red corpuscles* and *white corpuscles*. Blood which has been removed from the blood-vessels and exposed to the atmosphere under ordinary conditions coagulates. The coagulation is due to the formation of *fibrin*, a web-like substance which holds in its meshes the red and white corpuscles and separates them from the remaining liquid substance, which is called *serum*.

The coagulation of blood may be hindered or prevented by the addition of certain compounds. Among these may be mentioned sodium sulphate ( $\text{Na}_2\text{SO}_4$ ), magnesium sulphate ( $\text{MgSO}_4$ ), and the oxalates. The action of the oxalates is due to the precipitation of the calcium salts which are present in blood and are necessary for the formation of fibrin.

The following is the composition of plasma:

Water.....	90.29
Solids.....	9.71
Proteins (to yield fibrin).....	0.40
Proteins (other).....	7.86
Extractive fats.....	0.566
Inorganic salts.....	0.884

The white corpuscles, or, as they are sometimes called, *leucocytes*, are typical animal cells. The red corpuscles are made up largely of water and hæmoglobin and are the oxygen-carrying constituents of the blood.

**SWEAT**

Sweat is secreted by the sweat-glands, and the volatile portions pass off as vapor or are deposited as drops on the skin. It is a turbid, salty fluid, with a characteristic odor due to certain volatile, fatty acids. Its reaction is usually slightly acid, due to the presence of acid salts; but in profuse sweating it may be neutral or alkaline.

**COMPOSITION OF SWEAT**

Water.....	98.88
Solids.....	1.12
Salts.....	0.57
Sodium chloride.....	0.32
Other salts.....	0.25
Fats.....	0.30
Epithelium.....	0.17
Urea.....	0.08

The amount of sweat secreted by a man varies from one and a half to four pounds daily. The quantity varies with the temperature and the amount of exercise taken.

One of the functions of the skin is to regulate the temperature of the body. When a liquid passes into the vaporous condition, heat is absorbed. If the finger is dipped in ether and removed, a cool sensation follows, due to the evaporation of ether and absorption of heat from the finger. In like manner the body temperature is lowered when liquid sweat evaporates on the skin, because of the absorption of heat from the body.

## CHAPTER XXIII

### URINE AND URINALYSIS

URINE is a fluid secreted by the kidneys. The average amount of urine for an adult daily ranges from 1000 to 1500 Cc. Of this amount about 2.8 per cent. is urea, 95 per cent. water, and the remaining 2.2 per cent. is made up of inorganic and organic salts, the larger portion being sodium chloride. Normal urine is a transparent, pale yellow or amber fluid, usually acid in reaction, and having a characteristic odor. The average *specific gravity* is 1.020, when passed in quantity of 1500 Cc. in twenty-four hours. The *color* varies with the season, the amount of liquid taken into the body, etc. The *acid reaction* is due to sodium phosphate ( $\text{NaH}_2\text{PO}_4$ ) principally, although acetic, uric, and hippuric acid salts are also present.

CHEMICAL ANALYSIS	
Water.....	950.00
Urea.....	28.00
Uric acid.....	0.60
Hippuric acid.....	0.35
Creatinine.....	0.60
Extractives.....	8.50
Sodium chloride.....	7.50
Phosphoric acid.....	2.00
Sulphuric acid.....	1.25
Lime (CaO).....	0.25
Magnesia (MgO).....	0.35
Potash and soda.....	0.60

Pathological urine has a varying composition, depending on the abnormal condition which gave rise to it. The analysis of urine often lends aid in diagnosis. In selecting a specimen of urine for examination it should be a part of the whole twenty-four hours' urine, otherwise the specific gravity, color, reaction, and other properties may vary. If the twenty-four hours' quantity is not obtainable, a part of that passed before breakfast may be used.

The color, odor, general appearance (whether clear, smoky, cloudy, turbid, etc.), reaction (acid, alkaline, neutral), quantity passed in twenty-four hours, and the specific gravity are first noted.

As already stated, the average specific gravity is 1.020. A low specific gravity (1.010) indicates some pathological condition like nephritis, etc., while a high specific gravity (1.030) indicates diabetes (dextrose).

### EXAMINATION FOR INORGANIC MATTER

Evaporate some urine to dryness on a water-bath, ignite the brown residue over the open flame to destroy the organic matter, dissolve the residue in some distilled water with the aid of a small amount of diluted nitric acid, and test parts of the resulting solution for *potassium*, *sodium*, *calcium*, *magnesium*, *iron*, *hydrochloric acid*, *sulphuric acid*, and *phosphoric acid* as with saliva (pages 166 and 167). Test also for *ammonium* compounds, using lime water ( $\text{Ca}(\text{OH})_2$ ) in the place of potassium hydroxide.

### DETERMINATION OF UREA ( $(\text{NH}_2)_2\text{CO}$ )

Urea is usually determined quantitatively with an instrument called a "Ureometer" (see Figs. 39 and 40). Fill the ureometer



FIG. 39.—Doremus ureometer.



FIG. 40.—Doremus-Hinds ureometer.

with the hypobromitesolution, then slowly introduce with the special pipette one cubic centimetre of the urine, allowing the gas that is liberated to collect in the longer arm of the tube. Read off the number of divisions of the ureometer occupied by the gas. Each division represents 1 milligramme of urea for the quantity of urine used (1 Cc.).

The weight of the urine can be calculated from its specific gravity, and the percentage of urea can be determined from this weight and the weight of urea found in one cubic centimetre.

### TEST FOR URIC ACID

Make some urine acid with hydrochloric acid and allow it to stand for some time. The uric acid will be set free and crystallize out in the bottom of the vessel as hard grains, somewhat resembling sand. The **Murexid test** may then be carried out on these crystals, which can be removed by filtration or decantation. Place some of the crystals in a dish, add one or two drops of concentrated



FIG. 41.—Ruhemann's uricometer.

nitric acid, and evaporate to dryness on a water-bath. Cool and add one drop of ammonium hydroxide. A bright purple color (due to ammonium purpurate) indicates **uric acid**.

A rapid quantitative determination of uric acid may be made by using Ruhemann's uricometer (Fig. 41).

### ABNORMAL CONSTITUENTS

Of the abnormal constituents of urine, the following are more commonly determined:

#### 1. *Albumin*

Carry out the heat and Heller's tests, as described under proteins (page 149), on portions of urine.

An albuminometer (Fig. 42) may be employed for a quantitative determination.

#### 2. *Dextrose*

The reagent known as "Fehling's solution" is usually employed to show the presence of dextrose. It consists of two separate parts.

Make Fehling's solution as follows:

**Solution 1.**—Dissolve 34.67 grammes of pure copper sulphate in enough distilled water to make 500 Cc. Place in bottle.

**Solution 2.**—Dissolve 173 grammes of crystalline potassium and sodium tartrate ("Rochelle salt") and 75 grammes of potassium hydroxide in enough water to make 500 Cc. Place in *rubber-stoppered* bottle.

Equal volumes of Solutions 1 and 2 are well mixed and used for the test.

**Fehling's Test.**—Take 5 Cc. each of Solutions 1 and 2 in a test-tube and boil. Then add a few drops at a time of the urine under examination and boil again. Allow the mixture to stand, and note if there is any red or yellow precipitate ( $\text{Cu}_2\text{O}$ ), which indicates the presence of dextrose. It may be necessary to add urine several times and to boil after each addition before any precipitate appears, especially if the amount of dextrose is very small.

The saccharometer (Fig. 43) and the urino-glucosometer (Fig. 44) may be employed for quantitative estimations.

### 3. *Acetone*

"Legal's test" may be carried out as follows: To a quarter test-tube full of urine add a few drops of a fresh, concentrated solu-



FIG. 42.—Esbach's albuminometer.

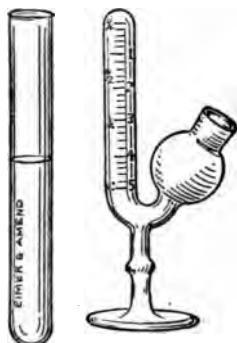


FIG. 43.—Einhorn's fermentation saccharometer.

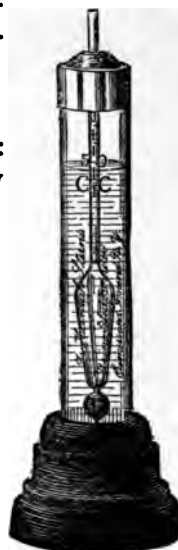


FIG. 44.—Sterns urino-glucosometer.

tion of sodium nitroprusside ( $\text{Na}_2\text{Fe}(\text{CN})_5\text{NO}$ ) and a few drops of acetic acid (to prevent a reaction with creatinine), and then make the mixture alkaline with ammonium hydroxide. The gradual development of a red color, deepening to purple-red, indicates **acetone**.

### 4. *Excessive Urea and Uric Acid*

Excessive amounts of urea and uric acid would be determined by means of the ureometer and uricometer (Figs. 39, 40, and 41).

### 5. *Excessive Indican*

Indican (indoxyl-potassium sulphate,  $C_8H_6NO.SO_2OK$ ) is normally found in urine in daily amounts of about 6.6 milligrammes. Pathogenic conditions give rise to excessive amounts of the compounds. The following *test* may be carried out. Add to one-eighth test-tube full of urine one-quarter as much hydrochloric acid and a few small crystals of potassium nitrate. Boil the mixture, allow it to cool, and shake with 2 Cc. of chloroform. Allow the chloroform to settle. If indican is *normal* in amount, the chloroformic layer will be *colorless*. If indican is in *excess*, the chloroformic layer will be colored from a light blue to a deep purple. (*Iodides*, taken internally, interfere with this test, since they will color the chloroformic layer blue; however, in the case of the blue color being due to iodides, sodium thiosulphate solution ( $Na_2S_2O_3$ ) will decolorize the mixture.)

### 6. *Blood*

Blood in the urine usually manifests itself by imparting a blood-red or brownish color with a bluish, greenish, or smoky tint, unless present in but slight amounts. It may be detected by making the sample alkaline with sodium hydroxide and boiling. In the presence of blood the precipitated phosphates are colored red. Bile-pigments and other coloring matters may interfere; in such cases, filter off the precipitate, wash, and dissolve it in acetic acid. In the presence of blood-pigment the resulting solution becomes red, but the color gradually disappears upon exposure to light.

### 7. *Bile*

Bile may be tested for by mixing the urine, contained in a test-tube, with a concentrated solution of sodium nitrate, and carefully pouring down the side of the tube concentrated sulphuric acid in such a manner as to form a distinct layer. At the point of contact of the two layers of liquid a play of color is seen, the colors changing from green to blue, violet-red, and yellow-green. Although the appearance of all the colors mentioned is not essential for the establishment of the presence of bile, it is indispensable that the green color appear first to prove its presence.





**PART V**  
**FERMENTATION AND FERMENTS**  

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**DISINFECTANTS, DEODORANTS AND**  
**ANTISEPTICS**



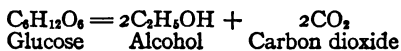
## CHAPTER XXIV

### FERMENTATION AND FERMENTS

THE term "*fermentation*" is used to designate the chemical decomposition which takes place in organic substances due to the presence of *microorganisms* or to "*enzymes*" (*i.e.*, certain excretions of microorganisms or secretions of living tissue). The agents that produce such chemical decomposition are known as "*ferments*." (They were so named because of the effervescence resulting from the treatment of weak sugar solutions with yeast.) Ferments are probably present in every cell, and take part in the vital changes. The liver contains eleven ferments. The spontaneous decomposition of bodies (autolysis) is due to the action of normal ferments in dead tissue.

When flour is mixed with water a tough "dough" is obtained, because of the presence of *gluten*, a protein, in the flour. (Gluten derived its name from the fact that it becomes glue-like in consistence when moistened with water.) If such dough is baked without further treatment, a hard mass is obtained. However, if the dough is allowed to stand exposed to the air, it undergoes changes due to the presence of yeast-cells and lactic acid bacilli that fall in from the air. These organisms grow and multiply, the lactic acid bacilli acting on the starch of the flour and converting it to glucose, and the yeast-cells causing the conversion of the glucose to alcohol and carbon dioxide.

The conversion of glucose to alcohol and carbon dioxide may be represented by the following equation:



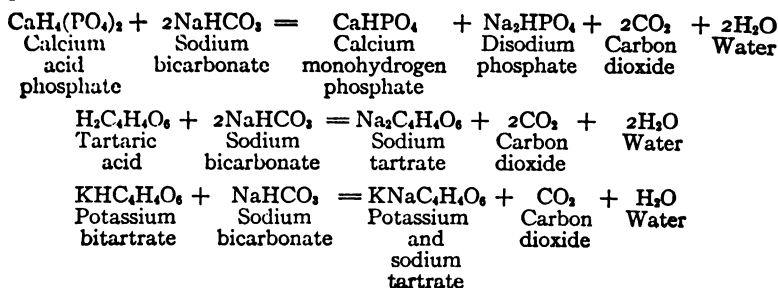
This process, then, is a "fermentation process," and the agents causing the fermentation are ferments.

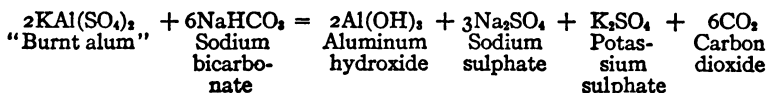
The carbon dioxide gas produced in the dough cannot escape from the pasty mass, and causes the dough to *rise*; that is, to

swell up in bubbles, in its efforts to escape. When the dough is baked the heat (1) causes the evaporation of the alcohol, (2) makes the bread spongy, (3) breaks up those starch grains that have not been affected by the ferment, and (4) causes the conversion of some of the starch of the outer portions (which have become much hotter than the inner portions) into dextrine, which is pasty in consistence and adheres to starch grains and other constituents of the bread forming the *crust*.

"Black bread" is made by allowing bread dough to stand in the air for some time to sour, the souring being caused by the formation of lactic and other organic acids. Fresh yeast is usually employed for making "white bread."

As substitutes for yeast "baking powders" are used. These powders contain ingredients which, in the presence of water, react and liberate carbon dioxide gas, which permeates the dough and causes it to rise. Some baking powders consist of a mixture of sodium bicarbonate, calcium acid phosphate, and starch. When this mixture is kneaded into the dough, the water present brings on a reaction between the sodium and calcium salts with the production of carbon dioxide gas in such amounts that the dough becomes spongy and ready for baking. The starch in a baking powder takes no part in the reaction, but simply gives bulk to the mixture. Other powders contain tartaric acid and sodium bicarbonate, potassium bitartrate ("cream of tartar") and sodium bicarbonate, or "burnt alum" and sodium bicarbonate. The equations illustrating the reactions that take place with the powders follow:





Of course, the process described in this paragraph would *not* be called fermentation, since the decomposition was not effected by microorganisms or enzymes.

If liquids that contain small amounts of fermentable sugars<sup>1</sup> are exposed to the air, they undergo decided changes in properties and composition. (Very concentrated solutions of sugar are not readily affected by such treatment, but instead possess preservative properties.) The change produced is caused by the yeast organism (*Saccharomyces cerevisiæ*). The products of the change are alcohol and carbon dioxide.

The juice of fresh grapes is the most easily fermentable liquid. It contains grape-sugar ( $\text{C}_6\text{H}_{12}\text{O}_6$ ), and, in addition, those substances required for the growth of the yeast organism. The product of the fermentation of grape juice is called **wine**. The quantity of grape-sugar in the juice of different kinds of grapes varies, therefore the quantity of alcohol in wines also varies. There is a limit to the *natural* alcoholic percentage of a wine, for, when the fermenting liquid reaches about 16 per cent. by volume of alcohol, the yeast organisms die. Those wines which contain more than this percentage of alcohol by volume have been "fortified"; *i.e.*, alcohol has been added. *Fortification* is usually carried out to make the wine keep better. The aroma which develops as the wine ages is due to the formation of certain organic compounds produced through the agency of bacteria. Small quantities of bacteria have been found in bottled wines thirty and forty years old.

**Cider** and **perry** are the alcoholic liquids obtained by the fermentation of the juices of apples and pears. Since the juices of these fruits contain only very small quantities of sugar, the product of their fermentation would be very poor in alcohol; therefore sugar is added to the juice before fermenting.

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<sup>1</sup> Not all sugars are directly fermentable. Cane- and milk-sugar cannot be fermented directly. However, if fermentation is begun in a mixture containing either of these sugars, they are converted into fermentable sugars.

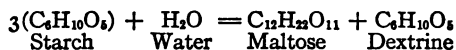
**Champagne** (from the name of the district where this wine was prepared since the seventeenth century) is prepared by allowing the juice of grapes to ferment and pouring the fermenting juice, after the first *energetic* fermentation is over, into bottles, which are immediately corked tightly. More carbon dioxide gas is generated as the "after-fermentation" proceeds in the bottle, and the wine becomes highly charged with carbon dioxide. (This excess of gas causes the popping sound when the bottles are opened.) The bottled wine is kept for some time before marketing. Champagne contains from 8 to 10 per cent. of alcohol and is high in sugar content. Cheap "champagnes" can be purchased, but these are made by simply charging sweetened, light white wines with carbon dioxide gas in the same manner as in making "soda water." The product is immediately placed on the market.

**Beer** is the product of fermentation of an infusion of farinaceous grains with various bitter materials, or we may say that it is the alcoholic beverage resulting from the fermentation of *malted barley* and *hops*. **Lager beer** is the name applied to any beer that has been stored several months. **Bock beer** is an extra strong beer brewed for spring use and made in limited quantities, not being intended for storage. **Ale** is really the English name for beer. It is usually lighter in color and contains a higher percentage of sugar than lager beer. **Porter** is a dark ale, the deep color of which is due to the use of brown malt dried at a high temperature. **Stout** is an extra strong porter, containing a high percentage of alcohol. The percentage of alcohol in beer varies from about 3 to 7.

In the manufacture of beer two distinct processes are involved, viz., "**malting**" and "**brewing**." **Malt** is made by steeping barley in water and then placing it in cellars, where the temperature is not too low, until it sprouts. During the sprouting the ferment **diastase**, which has the power of converting starch to sugar, is formed. When the sprouts have reached a certain length, the barley is spread out in layers and dried by heat. This dried product is **malt**. The *object of malting* is the production of diastase. The malt contains much more of the ferment than is necessary to

convert the starch contained therein to the complex sugar maltose ( $C_{12}H_{22}O_{11}$ ), and is capable of acting on the starch of a large quantity of grain mixed with it.

**Brewing** is carried out by first crushing the malt or mixture of malt and grain, and stirring it with water in tubs at a temperature of from  $50^{\circ}$  to  $70^{\circ}$  C. ( $120^{\circ}$  to  $170^{\circ}$  F.). The starch is converted to maltose and dextrine during this process, and the resulting liquor is known as "wort."



The clear wort is drawn off and boiled to sterilize and concentrate it. Then hops are added and the boiling is continued. Hops impart some of the resins, bitter principles, tannic acid, and volatile oil they contain to the wort. The boiled mixture is allowed to cool, and the clear liquid portion is run into fermentation-vats, where yeast is added and fermentation allowed to proceed. At the proper stage the beer is drawn off from the yeast, that separates out at the bottom or rises to the top, depending upon the temperature at which fermentation is allowed to take place, and is run into casks, where after-fermentation takes place. Finally, the beer is clarified with beech chips or shavings or with gelatine, to which the yeast organisms, as well as other solid impurities, attach themselves. It is then stored in barrels coated with pitch, or is pasteurized at  $60^{\circ}$  C. and bottled.

**Whiskey** is the liquor resulting from the distillation of fermented infusions of potatoes and grains, substances rich in starch. The potatoes, barley, rye, corn, rice, or oats, mixed with malt, are steeped in water. This is known as the "*mash*." The process used is similar to the one employed in the manufacture of beer, excepting that saccharous fermentation is allowed to proceed further, so as to obtain a maximum yield of maltose. Yeast is then added and alcoholic fermentation is allowed to take place. The fermented wort is distilled and redistilled, and placed in casks to "age" for a number of years. The "aging process" serves to soften and refine the flavor. At the same time, more or less color and flavor are extracted from the oak casks in which the



whiskey is stored. Another factor influencing flavor is the kind of grain used. Whiskey contains from about 30 to 46 per cent. by weight of alcohol.

**Artificial whiskey** is made by diluting alcohol with water, coloring with caramel or aniline dyes, adding prune juice as a "body," and flavoring with volatile oils or artificial fruit essences.

**Alcohol**, as we can see from the above, is a product of the fermentation and subsequent distillation of substances containing starch or sugar. Thus, any of the materials used in the manufacture of whiskey, wines, etc., can be used for the manufacture of alcohol. In the case of fruits, sugar already exists in their juices, which almost immediately, on exposure to the air, after expression, begin to undergo spontaneous, alcoholic fermentation. In the case of grains, saccharous fermentation must first take place; *i.e.*, the conversion of starch to sugar. As already stated, alcoholic fermentation is usually accomplished by the addition of yeast. After alcoholic fermentation is allowed to proceed, the mixture is distilled, as in the case of whiskey, and the distillate is subjected to repeated redistillation until an alcohol of the desired percentage strength is obtained. The product is not subjected to aging, etc., but is freed from fermentation by-products by the repeated redistillation. **Alcohol**, U. S. P., is 94.9 per cent. by volume; **Diluted Alcohol**, U. S. P., 48.19 per cent. by volume, and **Absolute Alcohol**, U. S. P., 99 per cent. by weight.

**Brandy** is the product of the distillation of the fermented juice of grapes (*wine*). It contains from about 20 to 50 per cent. by weight of alcohol.

**Rum** is the liquor distilled from fermented molasses or cane-juice. It contains from about 25 to 40 per cent. by weight of alcohol.

**Gin** is an alcoholic liquor flavored with the volatile oil of juniper, and sometimes with the volatile oils of fennel, anise, coriander, cardamom, and orange-peel. It contains from 30 to 40 per cent. by weight of alcohol.

**Koumis** is a stimulating beverage prepared by allowing milk to undergo alcoholic, lactic, and proteolytic fermentations. Only

a small amount of the koumis on the market is made from mare's milk, most of it being made from cow's milk.

**FERMENTS** may be divided into two classes: (I) **unorganized ferments** or **enzymes**, and (II) **organized or living ferments**. They may also be classified as (1) **proteolytic**, those which break proteins up into simpler products; (2) **amylolytic**, those which change starches to sugars; (3) **steatolytic**, those which split up fats; (4) **glycolytic**, those which break up complex sugars into simpler sugars; and (5) **coagulant**, those which curdle or clot.

I. **Unorganized ferments** or **enzymes** have already been defined as certain excretions of microorganisms or secretions of living tissue. In animal tissue they exist in an inactive, complex state, and only become active when exposed to the action of alkalies, acids, or air. For example, pepsin exists as pepsinogen. They are soluble in water and glycerin, but are insoluble in alcohol. They usually act best at about the temperature of the human body. Cold inhibits their action, and temperatures much above 45° coagulate them.

The **enzymes** may be divided into (a) **vegetable** and (b) **animal**.

(a) The most important **vegetable enzymes** are diastase, lactase, maltase, cellulase, inulase, saccharase, pectinase, emulsin, papain, invertin, bromelin, and zymase.

**Diastase** is the most important of the foregoing. It is derived from the gluten of sprouting cereals, like barley, and is capable of converting 3000 parts of starch to maltose.

**Lactase** converts lactose into two monosaccharose groups.

**Maltase** converts maltose to glucose.

**Cellulase** converts cellulose to sugar.

**Inulase** converts inulin to fructose.

**Saccharase** converts cane-sugar to dextrose and levulose.

**Pectinase** converts pectin to reducing sugar.

**Emulsin** converts amygdalin to dextrose and prussic acid (HCN).

**Papain**, found in the milky juice of the paw-paw tree, is a proteolytic ferment occurring as a white, granular powder. It is peculiar in that it will act in feebly acid, alkaline, or neutral media. It curdles milk.

**Invertin** changes cane-sugar to glucose.

**Bromelin** is a proteolytic ferment found in pineapples.

**Zymase** causes alcoholic fermentation of glucose.

(b) Of the **animal enzymes**, pepsin, trypsin, and erepsin (*proteolytic*), ptyalin and amylopsin (*amylolytic*), invertase (*glycolytic*), pancreatin (a mixture of ferments), steapsin (*steatolytic*), rennin (*milk-curdling*), and chymase are the more important.

**Pepsin** is secreted as *pepsinogen* by the glands of the stomach and requires hydrochloric acid to render it active. Diluted antiseptics and 0.1 per cent. of sodium chloride favor its action, but alkalis, tannin (tea and coffee), alcohol, sugar, excess of hydrochloric acid, and metallic salts (with the exception of calomel) retard its action. It converts proteins into peptones. The United States Pharmacopœia requires that pepsin be capable of digesting 3000 parts of freshly-precipitated egg albumin in six hours.

**Trypsin**, found in the pancreatic juice, acts in a manner similar to pepsin, but is more powerful. It requires a slightly alkaline medium.

**Erepsin**, found in all organs of the body, converts peptones and albumoses into amido-acids.

**Ptyalin**, found in the saliva, acts best on starch that has been boiled, since boiling ruptures the walls of the starch grains.

**Amylopsin**, present in the pancreatic juice, acts in a manner similar to diastase, converting starch to maltose (or, at times, glucose). Its action is favored by the presence of bile.

**Invertase** is the active ferment of the intestinal juice. It is capable of converting 200,000 parts of sugars to glucose. There are similar ferments in the pancreatic juice, saliva, blood, and other tissues.

**Pancreatin** is a mixture of ferments usually obtained from the fresh pancreas of the hog. It is a cream-colored, amorphous powder consisting chiefly of the ferments amylopsin, steapsin, trypsin, and myopsin, and should be capable of converting at least twenty-five parts of starch into soluble compounds.

**Steapsin** is found in the pancreatic juice and also in the bile. It splits fats and oils into glycerin and fatty acids. The fatty acids

are saponified by the sodium carbonate present, and the resulting soaps emulsify any remaining fats.

**Rennin** is found in the stomach and pancreas, curdles milk, and acts best in acid media. Excess of acid, as well as alkalies, destroys it.

**Chymase**, a specific ferment of the gastric juice, stimulates the action of pancreatic ferments.

**Histozym**, another animal ferment, is found in the kidneys. It converts benzoic acid into hippuric acid and glycocoll.

The enzymes excite the formation of "antibodies," which, when injected into new animals, bring about the formation of still other antibodies.

II. The **organized or living ferments** are low forms of vegetable life, mostly bacteria. They produce proteolytic, amylolytic, steatolytic, and glycolytic, as well as pathogenic fermentations in the organism. One striking difference between them and enzymes is that antiseptics inhibit their growth. They are killed at a temperature of  $100^{\circ}$ , excepting a few spores. Moisture is essential to their action. They contain cellulose, albumin, fat, and inorganic salts. Their action is due to the *unorganized ferments* (enzymes) they secrete.

The **yeast** plant is a fungus, appearing in oval budding forms of several varieties, widely distributed through the vegetable kingdom and in the air. It grows very rapidly by the multiplication of its cells if a favorable medium, like malt wort, is present and the temperature, etc., are also favorable. Under such favorable conditions it forms a viscous, yellowish, frothy substance. Its chief uses are (1) in the production of alcohol and alcoholic beverages and (2) in bread-making. Yeast is capable of decomposing 95 per cent. of glucose to alcohol, but, as already stated, it is killed when the alcoholic percentage reaches about 16 per cent. The yeast-cells produce the enzyme invertase, which converts cane-sugar to glucose, which in turn is converted to alcohol and carbon dioxide.

The yeast most commonly employed in bread-making is "**compressed yeast**," which is a product of distilleries where malt and

grains are fermented in the manufacture of "spirits." Most of it comes from whiskey wort. In the manufacture of compressed yeast, the yeast that floats on the top of the wort is skimmed off and is known as "*top yeast*," while that which settles to the bottom is removed by running the wort into settling trays and is known as "*bottom yeast*." Top yeast is considered more desirable for bread-making. The yeast is then washed through sieves, to remove the coarse particles of solid matter, into barrels of fresh water, and is allowed to settle. The water is drawn off and the yeast is agitated with fresh water several successive times. The last wash water is drawn off and the yeast dried by pressure, cut into cakes, wrapped in tin-foil, and kept in cold storage until distributed. Some manufacturers mix starch with the yeast. Only fresh yeast should be used. When fresh, yeast has a creamy white color, is uniform throughout, has a fine, even texture, is not acid to the taste, and is moist but *not* slimy. Its odor resembles that of an apple. When stale it possesses a cheesy odor and is acid in taste.

"**Dry yeast**" is made by mixing fresh yeast with meal or starch to form a dough, which is carefully dried, cut into cakes, and wrapped in packages. It will keep almost indefinitely.

The natural fermentation of grapes is due to two varieties of yeast-fungus that grow upon the fruit.

**Mycoderma aceti** ("mother of vinegar") consists of aërobic streptococci which oxidize alcohol to acetic acid.

**Bacilli lacti** and **Bacilli butyrici** produce lactic and butyric acid fermentations, respectively, of proteins, sugars, and mucus. Intestinal colic is frequently due to the gaseous by-products.

**Micrococci ureæ** are the most common factors in ammoniacal fermentation of urine.

**Mucor mucedo**, a mould, causes alcoholic fermentation.

The mould **oidium albicans** collects in the mouths of undernourished persons and forms in part the tartar on the teeth.

**Nitrifying ferments** are oxidizing agents, and are capable of converting ammonia gas and albuminoids into nitric and nitrous acids. These acids, coming in contact with the mineral matter of surface waters or the soil, form nitrates and nitrites, which are

compounds essential to the growth of plants. The rootlet nodules of most of the Leguminosæ, like the pea, bean, etc., contain millions of these bacteria, which enable the plant to utilize the nitrogenous materials of the soil and air.

The ferments of putrefaction found in the intestines act on proteins principally, forming gaseous hydrogen and fatty acids, then ammonia, carbon dioxide, hydrogen sulphide, and phosphine gases, phenol compounds, etc., and, finally, peptones, toxalbumins, and ptomaines.

The pathogenic microorganisms of specific infections produce their ill effects principally by means of the toxins they form.

Cleanliness, cooking or freezing and sealing in air-tight vessels will prevent putrefaction and fermentation of foods.

## CHAPTER XXV

### DISINFECTANTS, DEODORANTS AND ANTISEPTICS

THE terms "disinfectant" and "disinfection," "deodorant" and "deodorization," and "antiseptic" and "antiseptis" ("asepsis") have been used in such a variety of ways that much confusion has arisen as to the correct meaning of the words.

A **disinfectant** or **germicide** is a substance that is capable of destroying germs which act injuriously on higher forms of animal life. It should also destroy the spores of pathogenic organisms, which are usually more resistant than the organisms themselves, and should not have any marked action upon higher forms of life. Before the germ theory was generally accepted, the word "disinfection" was employed to designate the destruction of infectious material and the removal of any offensive odors from the same. The simple removal or disguising of odors was looked upon as disinfection. There are a number of organisms which do not produce ill-smelling gases, but which do form poisonous compounds ("ptomaines") that may possess an aromatic odor. However, there are substances which will absorb or disguise unpleasant odors arising from organic matter without killing the germs producing the putrefaction or decay. Charcoal is a good example of such a substance. The use of perfumes is very likely a relic of the attempts of primitive man to destroy noxious odors. A *true disinfectant* must not only destroy offensive odors, but must kill the organisms that give rise to them.

A **deodorant** is a substance that absorbs or oxidizes foul odors. Many disinfectants are also good deodorants. Simple deodorants are rarely germicidal.

An **antiseptic** is a substance which prevents or arrests the growth of microorganisms. Antiseptics may or may not be germicidal.

An **antizymotic** is a substance that prevents fermentation or putrefaction.

An adjunct to the proper action of these agents is the removal of all dirt and filth.

## HEAT

The most efficient disinfectant is *moist heat*. At the temperature of boiling water ( $100^{\circ}$  C. or  $212^{\circ}$  F.) all pathogenic organisms

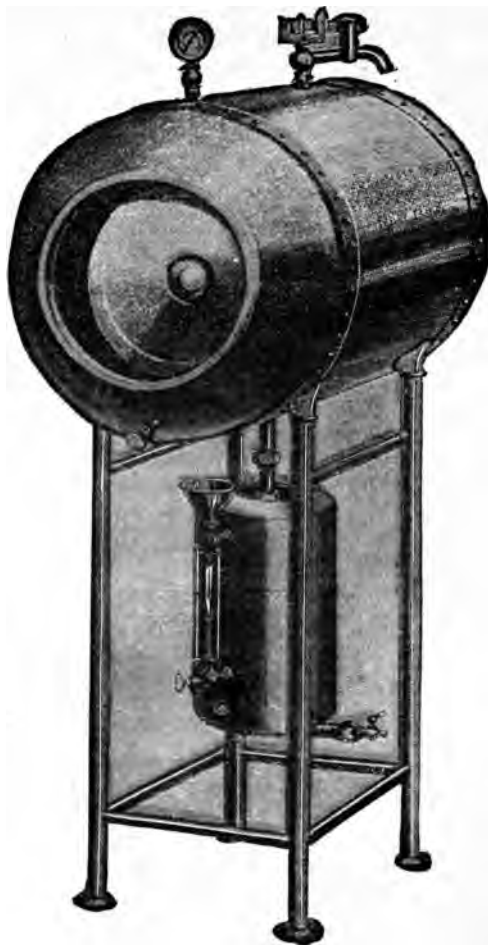


FIG. 45.—Steam sterilizer.

and their spores are destroyed within from five to ten minutes. *Dry heat* is less effective. When necessary to resort to the dry



method, the heat should be applied at about 300° F. *fractionally*; i.e., the material should be exposed to this temperature for a short period of time on successive days in order that the spores which have resisted the first application and which have developed into full-grown organisms may be killed by subsequent exposures. Usually three successive exposures, twenty-four hours apart, are sufficient. Disinfectants and antiseptics act more powerfully in warm water than in cold. Ten minutes are required to kill the tubercle bacilli in water heated to 70°; boiling water kills them in five minutes. They resist *dry* heat at 100° for several hours. The typhoid organism has been known to retain its vitality for months in ice.

For sterilizing instruments for an operation, the best method is to boil them for at least five minutes in pure water containing about 2 per cent. of sodium carbonate ("washing soda,"  $\text{Na}_2\text{CO}_3$ ). The sodium salt prevents rusting, and at the same time removes any adhering fat or grease. Gauze, dressings, etc., should be sterilized by steam heat immediately before using. Clothing, bedding, etc., should be sterilized by steam heat in the special apparatus provided for such materials (Fig. 45). Unfortunately, boiling decomposes a number of the compounds used hypodermically, such as atropine, cocaine, etc.

### PHENOL

The disinfectant efficiency of phenol ("carbolic acid,"  $\text{C}_6\text{H}_5\text{OH}$ ) is well known. A 5 per cent. solution of the compound in water is most generally employed, and is a fairly reliable antiseptic for general purposes, although certain bacteria and spores resist the action of the compound in any strength. This strength solution (5 per cent.) is used to sterilize such instruments as would be injured by heat. The five as well as the two per cent. solution is used as a wash. For disinfecting fæces and cloths a solution of six ounces of phenol to one gallon of water is very efficient. "Carbolized soap solution" is prepared by dissolving 3 per cent. of soft soap and 5 per cent. of commercial phenol in water. Phenol is active in the presence of oily and sebaceous materials. It

coagulates albumin. Beside its disinfectant property, phenol is also a local anæsthetic.

The chief objections to phenol are: (1) it may cause systemic poisoning, (2) it dulls instruments, (3) it benumbs and corrodes the hands of the operator.

Since phenol is soluble in about twenty parts of water at ordinary room temperature, an aqueous solution of not more than 5 per cent. should be used. If a stronger solution is attempted, the excess of phenol will separate out at the bottom of the bottle. Glycerin increases its solubility, and should be added in sufficient amounts to insure the solution of the phenol where more than 5 per cent. solutions are called for. Weak solutions of phenol have caused gangrene. They should not be employed upon children.

Alkaloidal solutions may be preserved by adding a few drops of phenol to each ounce of solution, although some question the advisability of such procedure.

### MERCURIC CHLORIDE

Mercuric chloride ( $\text{HgCl}_2$ ) ("corrosive sublimate," "bichloride," etc.) has become very popular as a disinfectant, although authorities disagree as to its relative activity in diluted solutions. Generally speaking, a 1 to 1000 solution is used for non-spore-bearing organisms, and a 1 to 500 for spore-bearers. Solutions as weak as 1 to 15,000 are said to possess general germicidal properties.

The addition of citric and tartaric acid to solutions of mercuric chloride assists in the penetrating of the compound into the tissues. The addition of sodium chloride to a mercuric chloride solution diminishes the disinfecting power of the latter. The compound combines with albumin, forming an insoluble compound (albuminate of mercury).

The objections to this compound are: (1) It is very corrosive to metallic instruments. (2) Strong solutions roughen the hands. (3) It is quite irritating to the tissues. (4) If a grain or more is absorbed, toxic symptoms are produced. (5) It is inactive in the presence of soap and fat. (6) Upon standing, aqueous solutions tend to become reduced to mercurous chloride ("calomel").

The compressed tablets, each of which usually contains seven and one-half grains of mercuric chloride mixed with citric acid, tartaric acid, or ammonium chloride, and colored blue or green, are employed in very large quantities. They should be kept in a bottle of peculiar shape, conspicuously labelled "**POISON**," and under lock and key. Many fatal accidents have resulted from the careless handling of these *harmless-looking, highly poisonous* tablets.

In treating poisoning by corrosive sublimate the stomach should be evacuated if vomiting has not already occurred. Milk, magnesia, flour mixed with water, and white of egg may be employed. If white of egg is used an *excess* must be avoided, as the albuminate of mercury formed becomes soluble in excess of the egg-albumin. The white of one egg may be given for every four grains of the corrosive sublimate taken. The heart, circulation, and respiration should be stimulated, artificial heat employed, and opium or morphine given to relieve pain and nervous irritability.

#### MERCURIC CYANIDE

This compound ( $\text{Hg}(\text{CN})_2$ ) is less germicidal than the bichloride.

#### POTASSIUM PERMANGANATE

Potassium permanganate ("permanganate of potash,"  $\text{KMnO}_4$ ) is an efficient disinfectant. All organisms, excepting the tubercle bacillus, are killed by a 5 per cent. solution.

The compound is used for disinfecting the surgeon's hands as follows: The nails, hands, and arms are first thoroughly scrubbed with soap and hot water; they are then immersed in a saturated solution of potassium permanganate, and finally immersed in a saturated solution of oxalic acid to remove the purple stain of the permanganate. The last step may give rise to itching, but this may be overcome by immersing in *sterilized* lime water.

The disadvantages of this compound are: (1) It is not adapted to internal administration (except in very dilute solution), because it is irritating to the stomach. (2) It leaves a brown stain on fabrics and, if strong, corrodes them. (3) Before attacking organisms, it

first oxidizes hydrogen sulphide, ferrous salts, nitrites, and most organic materials. (4) It is non-volatile, and, therefore, can act locally only. (5) It may explode in the presence of readily combustible substances.

A 1 to 200 solution is used as a mouth-wash, and solutions of from 0.5 to 5 per cent. as injections and washes.

### FORMALDEHYDE

Formaldehyde ("formic aldehyde," "formalin,"  $\text{HCOH}$ ) has become very widely used as a disinfectant, and has proved itself to be one of the most efficient. A 1 per cent. solution kills almost all forms of microorganisms in about thirty minutes. Although vapors of the compound have not the penetrating powers that other disinfectants possess, it disinfects surfaces completely and rapidly when the atmosphere is charged with from  $\frac{1}{2}$  to 2 per cent. of the vapors and even under the ordinary conditions of temperature and moisture found in living-rooms. The vapors do penetrate, to some extent, into loose fabrics, especially when these are dry. The colors of most textile materials are not materially affected, and the articles and rooms exposed can be readily cleared by sufficient aëration. With the exception of iron and steel, the metallic elements are not affected.

For the disinfection of rooms the vapors are usually produced by: (1) heating paraformaldehyde  $(\text{HCOH})_3$ , which breaks up into three molecules of formaldehyde  $(3\text{HCOH})$ ; (2) passing the vapors of methyl alcohol  $(\text{CH}_3\text{OH})$  through heated metallic coils, whereby the alcohol is oxidized to formaldehyde according to the equation:  $\text{CH}_3\text{OH} + \text{O} = \text{HCOH} + \text{H}_2\text{O}$ ; (3) heating the 40 per cent. aqueous solution, known as "formalin," with some glycerin (about 10 per cent) or some calcium chloride, either of which will dehydrate the gas; (4) hanging sheets which have been dipped in a diluted solution of formalin on lines in the rooms; (5) spraying the walls, ceilings, floors, etc., with a solution of formaldehyde, usually 1 to 1000. —

One of the most rapid and effective ways to liberate formaldehyde is to mix one part of crystalline potassium permanganate

with two parts of formalin in an asbestos-lined vessel. All windows, doors, cracks, etc., must be kept sealed for eight or ten hours. When the room is opened the irritating vapors of the gas may be overcome by warming some ammonia water in the room. Floors should be scrubbed thoroughly with some antiseptic solution, as well as the walls and articles of furniture. Clothing and bedding should be boiled.

Some boards of health provide formaldehyde lamps or formaldehyde-sulphur torches for room disinfection. The upper compartment of the lamp shown in Fig. 46 contains

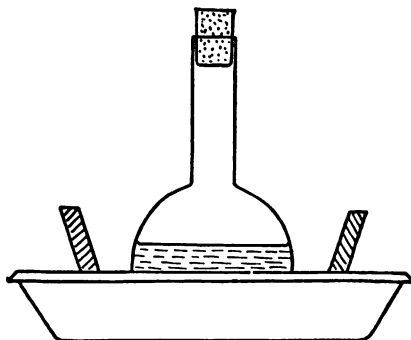


FIG. 46.—Formaldehyde lamp. (DePree's.)     FIG. 47.—Formaldehyde-sulphur torch. (Lee's.)

while the lower contains a wick embedded in wax. In the case of the formaldehyde-sulphur torch (Fig. 47) the flask contains a solution of formaldehyde mixed with some dehydrating agent like glycerin, and the tray some sulphur in which are embedded two wicks. By burning, the sulphur is converted into sulphur dioxide ( $\text{SO}_2$ ), a disinfectant gas, and the heat generated is sufficient to cause the liberation of the formaldehyde gas from the solution.

For general use, solutions of from  $\frac{1}{2}$  to 2 per cent. are used; for surgery, from  $\frac{1}{4}$  to  $\frac{1}{2}$  per cent.; for sterilizing catgut, a 4 per cent. Pastilles of paraformaldehyde are used for sterilizing catheters, etc., by keeping some of the pastilles in a closed box with the instruments. The clinical thermometer may be sterilized

by placing a few drops of formalin in the case. For general daily purposes in the school-room, office, theatre, etc., a formaldehyde spray is frequently employed. The "*Spray Ozone Sprayer*" is the most efficient of sprays for daily disinfecting purposes that have been examined by the authors. (See Fig. 48.)



FIG. 48.—Formaldehyde sprayer.

### HYDROGEN DIOXIDE

Hydrogen dioxide ( $H_2O_2$ ) is an oxidizing disinfectant which liberates free oxygen in the presence of all organic matter. It has a special affinity for pus, with which it effervesces. The compound, in the dilution usually employed (3 per cent.), is entirely non-poisonous. The principal disadvantages of the compound are: (1) its corrosive action on the metals; (2) its instability; (3) the likelihood of explosion when heating the confined solution.

### SILVER NITRATE

Silver nitrate ( $AgNO_3$ ) and its modifications, "lunar caustic" and "mitigated caustic," have been extensively used in most inflammatory and ulcerative conditions of the mucous membrane. Some have placed this compound next in antiseptic value to mercuric chloride. The disadvantages of silver nitrate are: (1) it discolors the tissue; (2) it is precipitated by the sodium chloride in the secretions; (3) when used internally over a long period of time it produces "argyria."

A number of excellent organic silver compounds are on the market and afford good substitutes for the nitrate. Among them are "Argyrol," "Protargol," "Albargin," etc.

Silver nitrate is used as an injection and irrigation in from 0.2 per cent. to 5 per cent. solution; Argyrol, from  $\frac{1}{4}$  to 1000 to 50 per cent.; Protargol, from 0.1 to 10 per cent.; Albargin, from 0.5 to 20 per cent. The nitrate is also used as a caustic for ulcers, wounds, etc.

### IODOFORM

Although authorities disagree as to the antiseptic value of this compound, its action is most likely due to (1) the fact that it acts as a desiccant, thereby starving the organisms because of the absorption of the secretions upon which they depend; and (2) the fact that it produces chemical changes in the toxic products thrown off by the bacteria. However, experiments have shown that there are some microorganisms which will grow in iodoform. Because of this, it is best to sterilize the compound by heat before using.

Iodoform is used in the form of ointment, solution, emulsion, gauze, and as a dusting powder. The compound should be applied with caution to fresh wounds. Large amounts should be avoided, since alarming symptoms of poisoning have followed the immoderate application of the compound to wounds, especially in children and old people. A valuable antidote is potassium bicarbonate. The principal objection to iodoform is its odor. A number of iodoform substitutes are on the market which have not a disagreeable odor, as "Aristol" (Thymol Iodide).

### CREOSOTE

"Beechwood creosote" is widely employed to stimulate digestion and prevent intestinal fermentation, especially in tuberculous patients. The chief objection to its use is its irritating properties, which result in serious digestive disturbances in many patients. If used in too large amounts it produces symptoms of poisoning that closely resemble those of phenol poisoning. Some investigators claim that a 1 per cent. solution fails to kill the bacillus of tuberculosis in 24 hours. "Wood creosote" should not be confused with "coal-tar creosote." The latter is very poisonous and is not employed in medicine.

### CRESOL

Cresol ("cresylic acid") is a more effective germicide than phenol, and is less poisonous and corrosive. Its solubility in water is increased by the presence of an alkali. In alkaline solution it readily penetrates albuminous materials. "Lysol," "Creolin," "Solutol," etc., are proprietary preparations containing cresols.

**HEXAMETHYLENAMINE**

Hexamethylenamine ("Urotropin," "Formin," etc.) is probably the most valuable general internal antiseptic. It is of special value as a genito-urinary antiseptic. In the urinary passages it liberates formaldehyde *only* when the urine is *acid*. It is given internally in doses of from 5 to 25 grains diluted with much water.

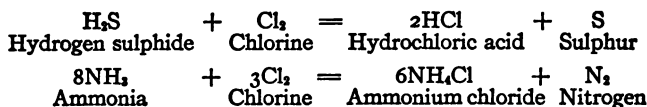
**GLYCERIN**

Glycerin, when present in sufficient amounts, is a good antiseptic. Its principal application as such is in the manufacture of vaccine. It has no effect on the tetanus organism.

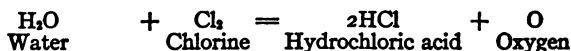
**THE HALOGENS****CHLORINE**

Soon after the discovery of this element, its disinfectant properties were recognized. The usual method for its derivation as a disinfectant is the treatment of chlorinated lime ("chloride of lime" or "bleaching powder") with a diluted acid. Chlorinated lime is used in large quantities for the disinfection and deodorization of sinks, water-closets, drains, evacuations, discharges, sputum, etc. The compound should always be placed in the vessel before the matter to be disinfected is deposited therein.

The disinfectant action of this halogen is dependent upon: (1) Its property of replacing the hydrogen in organic substances. This action, however, would not occur except in the presence of sunlight. (2) Its property of decomposing offensive gases; for example:



(3) Its most important and common property of liberating nascent oxygen, a powerful germicide, from water:



Chlorine gas, as a disinfectant, is similar to potassium permanganate, in that it does not affect the germs until present in excess;



*i.e.*, until any chemical reactions with other materials present are completed. Therefore, in disinfecting with chlorine, it follows that in order to obtain good results there must be a persistent odor of chlorine for some time.

Its compounds, the chlorides, such as sodium and zinc chlorides, are more or less disinfectant and antiseptic.

### BROMINE

Bromine is a powerful deodorizer and disinfectant. Its chemical action is similar to that of chlorine, which, however, is more active than bromine. The halogen cannot be used in the sick-room or operating-room because of the very irritating and corrosive fumes it gives off. Its salts, the bromides, are somewhat antiseptic.

### IODINE

The third member of the halogen group, although a more feeble oxidizer than either chlorine or bromine, combines more readily with the protoplasm of microorganisms, when in dilute solution, and poisons them. It is also more portable and convenient to use because of its solid nature. Since it is only slightly soluble in water (1 to about 5000), in surgery an alcohol solution is used; *i.e.*, the tincture of iodine (about 7 per cent.), or the tincture diluted with an equal volume of alcohol. The chief disadvantage of this halogen is the fact that it leaves brown stains on organic material. It is used as an irrigation in from 1:2000 to 1:10,000.

### FLUORINE

The fourth member of the halogen group, because of the intensity of its action and the difficulty with which it is prepared, is not a practical disinfecting agent.

### OXYGEN

Excepting in the case of anaërobic bacteria, *molecular* oxygen is *not* germicidal. However, *nascent* oxygen (*i.e.*, freshly liberated, *atomic* oxygen) is a very powerful germicide. Ozone (O<sub>3</sub>) owes its disinfectant properties to the nascent oxygen it breaks up into.



### SOAP

Ordinary soap possesses decided disinfectant properties. Many are of the opinion that soaps containing small quantities of disinfectants possess but little value over ordinary soap.

### ALCOHOL

Diluted alcohol is more germicidal than the strong. The antiseptic action of alcohol is due to (1) its coagulating effect on albumin, and (2) its dehydrating effect, by which microorganisms are deprived of the moisture necessary to their growth. It is used for washing open wounds, cavities, etc., for preserving solutions, anatomical specimens, etc.

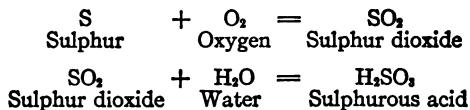
### ACIDS

#### MINERAL ACIDS

Hydrochloric, sulphuric, and nitric acids, as well as acids in general, are all slightly antiseptic, since most bacteria thrive best in neutral or alkaline media. Hydrochloric and nitrohydrochloric acids are now largely used in place of lactic acid in stomachic indigestion.

#### SULPHUROUS ACID

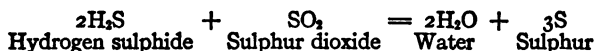
**Sulphur** has been employed as a disinfectant from the earliest times. It is used by burning the element in air, the gas sulphur dioxide ( $\text{SO}_2$ , sulphurous anhydride) being produced. This gas, in turn, combines with water vapor to form the excellent disinfectant **sulphurous acid** ( $\text{H}_2\text{SO}_3$ ).



Dry sulphur dioxide gas is not a disinfectant, therefore it is necessary to insure the presence of water vapor in the rooms and on the articles to be disinfected by placing vessels of water in the rooms and spraying objects with an atomizer before burning the sulphur. For fumigating with sulphur, the rooms should first be

thoroughly sealed, three pounds of sulphur should be burned for every 1000 cubic feet of room space, and the process should be allowed to proceed for at least twelve hours.

This agent acts in a fourfold manner: (1) It absorbs ammonia gas and organic bases, such as the ptomaines and the products of microörganic growth. (2) It decomposes hydrogen sulphide:



(3) It reduces or combines with organic matter, in most cases forming inert compounds. (4) It acts, in the presence of water, as a germicide.

The disadvantages of the compound are: (a) It is irrespirable, causing, when inhaled, violent coughing and suffocation. (b) It bleaches colored fabrics. (c) It corrodes metals.

Liquid sulphur dioxide is sold in steel cylinders for disinfectant and refrigerant purposes.

#### BORIC ACID

Boric acid ("boracic acid,"  $\text{H}_3\text{BO}_3$ ) is not a disinfectant, but does possess antiseptic powers, a 1 to 140 solution arresting the activity of most microörganisms. It has been used in large quantities as a preservative for meats, vegetables, and milk. The saturated solution deodorizes fetid perspiration, and is frequently employed for washing the eye, nose, mouth, and throat. Powdered boric acid is used by insufflations into the ear in treating diseases of that organ, and as a surgical dressing. Poisoning may result from the free use of the compound for the latter purpose. The acid is added to solutions of some alkaloids to prevent decomposition.

**Borax** (sodium tetraborate,  $\text{Na}_2\text{B}_4\text{O}_7$ ) is also slightly antiseptic, and is used for the same purposes as boric acid.

#### ACETIC ACID

Diluted acetic acid or "vinegar" ( $\text{CH}_3\text{COOH}$ ), scented with spices, was used in the Middle Ages, under the title "Aromatic vinegar," to drive away plague. It has been found by experimentation that a 3 per cent. solution of this acid will kill the typhoid

organism within six hours. A 7 per cent. solution is said to be as powerful an antiseptic as a 1 to 1000 solution of bichloride of mercury. Very diluted acetic acid has been used to bathe typhoid fever and scarlatina patients. It acts as a cooling tonic to the skin, assists desquamation, and covers offensive odors. Its salts, the acetates, are not antiseptic.

#### BENZOIC ACID

Although benzoic acid ( $C_6H_5COOH$ ) is not a germicide, it possesses sufficient antiseptic properties to prevent decomposition in meats, fats, milk, foods, etc. It forms one of the ingredients of most antiseptic mixtures. In medicine the acid has been given as an internal antiseptic in cystitis in doses of from 10 to 30 grains.

Its salt, **sodium benzoate**, is also largely used as an antiseptic in foods, catsup, milk, antiseptic mixtures and solutions.

#### SALICYLIC ACID

Salicylic acid is another one of the antiseptic, non-corrosive, organic acids. It has been used as a preservative for foods by manufacturers. Although efficient in the treatment of rheumatism, its salts, the **salicylates**, are generally employed because they are less disturbing to digestion. The acid and its salts are decomposed into phenol and carbonic acid in the intestines. The artificial acid, made from phenol, has frequently produced symptoms of poisoning.

**Oil of wintergreen** (methyl salicylate), **salol** (phenyl salicylate), and **sodium salicylate** are also used as antiseptics.

#### LACTIC ACID

Lactic acid is one of the products of alimentary fermentation. If present in sufficient amounts, it prevents fermentation.

#### TARTARIC AND CITRIC ACIDS

These acids have the general power of inhibiting the growth of those organisms which prefer neutral or alkaline media. It is said that a citric acid solution of 1 to 200 will kill the cholera spirilla, therefore the instructions to drink lemonade in times of cholera, typhoid, and other water-borne infections.

### TANNIC ACID

Tannic acid precipitates both albumin and gelatin. Because of the latter property it is used to make skins imputrescible in the manufacture of leather. Beside its valuable astringent property, it is somewhat antiseptic.

### CHLOROFORM

Beside its anæsthetic properties, chloroform possesses antiseptic properties. In medicine chloroform water and spirit of chloroform are of value in treating disturbances that are attended with flatulence and fermentation. The compound is used to preserve alkaloidal solutions and urine.

### ETHER

The chief use of ether in medicine is for anæsthesia. The compound, if undiluted, is a germicide.

### LIME AND SLAKED LIME

Lime ("quicklime," calcium oxide,  $\text{CaO}$ ) and slaked lime (calcium hydroxide,  $\text{Ca(OH)}_2$ ) are both used as disinfectants, although their disinfectant properties are matters of doubt. Fresh lime, it is true, does destroy organic matter by its dehydrating action, and, since but few microorganisms can remain active any length of time in a dry state, the desired end is accomplished. Lime is used principally for disinfecting manure-heaps. The use of lime water for preserving eggs depends upon the deposition of calcium carbonate in the pores of the shell, thereby rendering it impervious, and also to the coagulation of the albuminous envelope of the egg.

### ZINC PHENOLSULPHONATE

Zinc phenolsulphonate (zinc sulphocarbolate) is strongly antiseptic as well as astringent. It is odorless and non-irritating.

### COPPER SULPHATE

Copper sulphate ("blue stone," "blue vitriol,"  $\text{CuSO}_4$ ) is a strong disinfectant, being disinfectant in 1 to 120 solution, and antiseptic in 1 to 1000 solution. It coagulates albumin and absorbs ammonia and hydrogen sulphide.

**FERROUS SULPHATE**

Ferrous sulphate ("green vitriol," "copperas,"  $\text{FeSO}_4$ ) is moderately antiseptic, but is not a disinfectant. It is a deodorant, absorbing hydrogen sulphide and ammonia.

**CHROMIUM TRIOXIDE**

Chromium trioxide ("chromic acid,"  $\text{CrO}_3$ ) is a powerful, oxidizing germicide and antiseptic. It coagulates albumin instantly, combines with a large number of organic compounds, and gives a yellow or brown stain. It is very corrosive and irritating, death resulting from too free application of the compound.

**VOLATILE OILS AND STEAROPTENS**

The ancients were familiar with the antiseptic and insecticidal properties of such classes of compounds as the volatile oils, camphors or stearoptens, etc. The precious woods were those that contained volatile oils, like cedar and sandal-wood. These woods were used for making boxes and other containers intended for the reception of valuable documents and other articles that were to be preserved. The woods were also burnt for fumigating, were carried about the person to keep away disease, and were added to water and wines. The use of condiments may be explained on the assumption that they are more or less antiseptic and arrest fermentation in the alimentary canal. The volatile oils of **bergamot**, **birch**, **cajuput**, **chamomile**, **caraway**, **juniper**, **lemon**, **nutmeg**, **savin**, **sassafras**, **anise**, **sandal-wood**, **coriander**, **thyme**, **cloves**, **cedar**, **cubeb**, **cinnamon**, **wintergreen**, **mustard**, **lemon**, **orange**, and **turpentine** all possess antiseptic properties.

Of the foregoing oils, **turpentine** is perhaps most frequently employed. However, it is too irritating for surgical application. For ringworm, turpentine, in conjunction with tincture of iodine, is frequently employed. **Terpin hydrate**, a turpentine derivative, is also an antiseptic agent, and is employed internally in diseases of the lungs and kidneys.

Of the stearoptens or camphors, **menthol**, from oil of peppermint; **thymol**, from oil of thyme, and **eucalyptol**, from oil of eucalyptus, are of greater importance and are useful antiseptics.

**Menthol** arrests fermentation, and, according to A. Macdonald, is about twice as powerful as phenol.

**Thymol** is strongly antiseptic, having one-fourth the potency of phenol. It is specific against hookworm. It is one of the usual ingredients of antiseptic solutions, used in respiratory affections in the form of sprays and inhalations. Externally it is useful in scaly skin diseases in the form of ointment.

**Eucalyptol** is also a strong antiseptic, credited with one-fourth the antiseptic powers of phenol. It is a common ingredient of antiseptic solutions and mixtures. In medicine it is used internally in the treatment of atonic ulcers, gangrene, chronic urinary diseases, etc. It is also used in the form of sprays and inhalations in respiratory affections.

#### QUININE

The alkaloid quinine and its salts are specially destructive to the *Plasmodium malariae*, even in a solution of 1 in 20,000. The sulphate, hydrochloride and hydrobromide are usually employed.

#### CHLORAL HYDRATE

Chloral hydrate, in the form of lotions or washes, is used in the treatment of parasitic diseases of the skin and of foul ulcers. It is also used as a urine deodorant.

#### ACETANILID

Powdered acetanilid is extensively used as an external antiseptic for wounds, ulcers, chancroids, etc. However, poisonous symptoms may follow its too free application.

#### RESORCIN

Resorcin ("resorcinol") is highly antiseptic if in proper strength (1 to 2 per cent.). Large doses produce symptoms similar to those of phenol poisoning, although the compound is far less poisonous than phenol. It is useful as a gastro-intestinal antiseptic, in the treatment of parasitic and scaly skin diseases, and as an ingredient of antiseptic soaps.

**PETROLEUM**

Crude petroleum and kerosene are extensively used to destroy the larvæ of mosquitoes by spreading on the surface of pools, ponds, etc., that are infested with the insects.

**NAPHTHALENE**

Naphthalene, more popularly known as "tar balls," "moth balls," or "coal-tar camphor," is used as a prophylactic against moths.





## APPENDIX



## WEIGHTS AND MEASURES

### TROY WEIGHT

(Used by goldsmiths and jewellers)

Pound		Ounces		Penny-weights		Grains
lb. 1	=	12	=	240	=	5760
		oz. 1	=	20	=	480
				pwt. 1	=	gr. 24

### APOTHECARIES' WEIGHT

Pound		Ounces		Drachms		Scruples		Grains
lb. 1	=	12	=	96	=	288	=	5760
		℥ 1	=	8	=	24	=	480
				ʒ 1	=	3	=	60
						ʒ 1	=	gr. 20

### AVOIRDUPOIS WEIGHT

(Used for commercial purposes)

Pound		Ounces		Grains
lb. 1	=	16	=	7000
		oz. 1	=	gr. 437.5

### APOTHECARIES' OR WINE MEASURE (*United States*)

Gallon		Pints		Fluidounces		Fluidrachms		Minims
Cong. 1	=	8	=	128	=	1024	=	61,440
		0 1	=	16	=	128	=	7,680
				℥ 1	=	8	=	480
						℥ 1	=	℥ 60

### IMPERIAL MEASURE (*British*)

Gallon		Pints		Fluidounces		Fluidrachms		Minims
C. 1	=	8	=	160	=	1,280	=	76,800
		0 1	=	20	=	160	=	9,600
				fl. oz. 1	=	8	=	480
						fl. dr. 1	=	min. 60

### APPROXIMATE MEASURES

The physician, in apportioning doses for the patient, is usually forced to order the liquid medicine to be administered in certain quantities that have been established by custom. It should be remembered that the measures given below are approximate. The authors have found that the measures used contain from fifteen to twenty-five per cent. more than their theoretical

equivalent. Physicians, pharmacists, and nurses should insist upon the use of the graduated medicine-glass, which can be purchased at any drug store for a very small sum.

1 tumblerful	= approximately.....	f3 viii
1 teacupful	= approximately.....	f3 iv
1 wineglassful	= approximately.....	f3 ii
1 tablespoonful	= approximately.....	f3 iv
1 dessertspoonful	= approximately.....	f3 ii
1 teaspoonful	= approximately.....	f3 i
1 drop, through popular error,	is considered the equivalent of 1 minim.	

### THE METRIC SYSTEM

This system was originated in France in 1790, and is now the legal standard in most countries. The system is based upon the *unit of length*, the *metre*, which is  $1/40,000,000$  part of the earth's polar circumference. The *unit of capacity*, the *litre*, which is the cube of  $1/10$  part of a metre, and the *unit of weight*, the *gramme*, which is the weight of that quantity of distilled water at  $4^{\circ}$  C. which will fill a cube of  $1/100$  part of a metre, were derived from this unit of length. The system is also known as the "Decimal System" because in obtaining the multiples and subdivisions the number 10 (Latin, *decem*) is used. The prefixes, indicating *multiplication* (Deka, 10; Hecto, 100; and Kilo, 1000), are of Greek origin; while those indicating *division* (deci,  $1/10$ ; centi,  $1/100$ ; and milli,  $1/1000$ ) are of Latin origin.

The following table gives the student a general view of the system:

1000 Kilometre, Km.	1000 Kilolitre, Kl.	1000 Kilogramme, Kg.
100 Hectometre, Hm.	100 Hectolitre, Hl.	100 Hectogramme, Hg.
10 Dekametre, Dm.	10 Dekalitre, Dl.	10 Dekagramme, Dg.
1 metre, M.	1 litre, L.	1 gramme, Gm.
.1 decimetre, dm.	.1 decilitre, dl.	.1 decigramme, dg.
.01 centimetre, cm.	.01 centilitre, cl.	.01 centigramme, cg.
.001 millimetre, mm.	.001 millilitre, ml.	.001 milligramme, mg.

**Unit of length = metre:**—One side of the diagram (Fig. 49) measures 1 *decimetre*. It is graduated into tenths or *centimetres*, and these tenths into tenths or *millimetres*.

**Unit of capacity = litre:**—A hollow cube having each side the same size as the square would hold a litre. (1000 Cc.)

**Unit of weight = gramme:**—The weight of distilled water at  $4^{\circ}$  C. contained in a cube the size of the one shown at the lower left-hand corner ( $1/1000$  of a litre or 1 cubic centimetre) equals a gramme.

### EQUIVALENTS

- 1 centimetre =  $1/100$  metre = 0.3937 inch.
- 1 cubic centimetre =  $1/1000$  litre = 16.23 minims, and weighs 1 gramme at  $4^{\circ}$  C. (water).
- 1 cubic foot = 1728 cubic inches = 28316.085 cubic centimetres.
- 1 cubic inch = 266 minims = 16.386 cubic centimetres.
- 1 cubic metre = 1000 litres = 35.315 cubic feet.
- 1 Apothecary drachm = 60 grains = 3.888 grammes.
- 1 fluidrachm = 60 minims = 3.696 cubic centimetres.

- 1 fluidounce (U. S.) = 8 drachms = 480 minims = 29.57 cubic centimetres,  
and weighs, if water, 455.7 grains or 29.57 grammes.  
1 foot = 12 inches = 0.30479 metre.  
1 gallon (U. S.) = 8 pints = 3.785 litres.

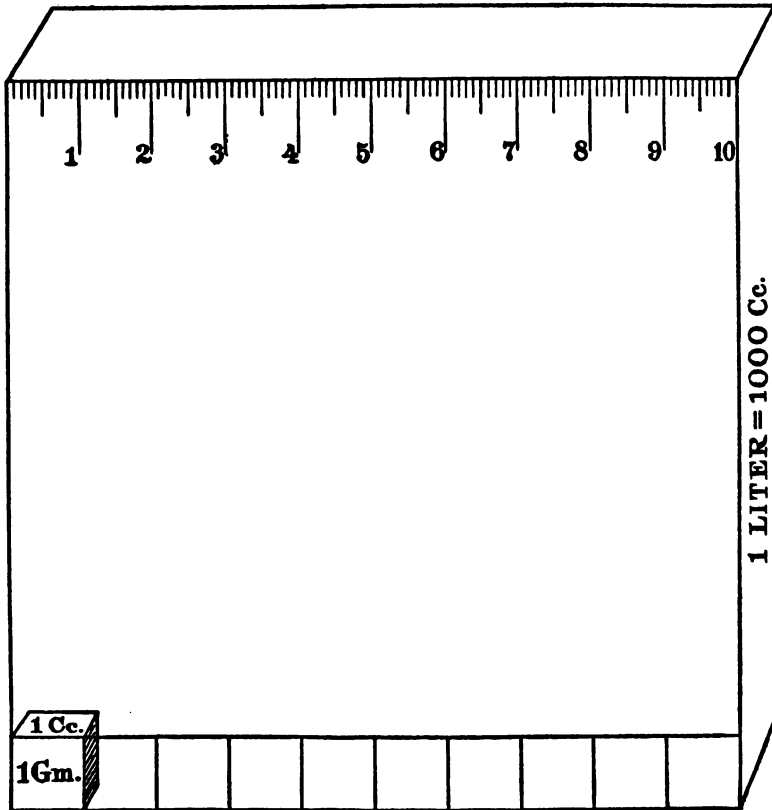


FIG. 49.—Each side of the square measures 1 decimetre, each decimetre is divided into tenths (*centimetres*), and each centimetre into tenths (*millimetres*). The dimensions of the cube then are 1 decimetre by 1 decimetre by 1 decimetre, or 1 *cubic decimetre* (1000 *cubic centimetres*). A hollow cube of these dimensions would hold a *litre* (1000 cubic centimetres). The small cube at the lower left-hand corner is a cubic centimetre (1/1000 of a cubic decimetre). The weight of *distilled water* at 4° C. contained in such a cube (1 cubic centimetre) is equal to a *gramme*.

- 1 grain = 0.0648 gramme.  
1 gramme = 15.432 grains.  
1 inch = 2.54 centimetres.  
1 kilogramme = 1000 grammes = 2.2046 Avoirdupois pounds.

1 litre = 1 cubic decimetre = 1000 cubic centimetres = 33.8 fluidounces.  
 1 metre = 3.28086 feet.  
 1 millimetre = 1000 micromillimetres = 1/1000 metre = 0.0393 inch.  
 1 minim = 0.0616 cubic centimetre, and weighs, if water, 0.95 grain.  
 1 Apothecary ounce = 480 grains = 31.1 grammes.  
 1 Avoirdupois ounce = 437.5 grains = 28.35 grammes.  
 1 pint (U. S.) = 16 fluidounces = 473.179 cubic centimetres.  
 1 pound (Apothecary) = 12 ounces = 5760 grains = 0.37324 kilogramme.  
 1 pound (Avoirdupois) = 16 ounces = 7000 grains = 0.45359 kilogramme.  
 1 quart (U. S.) = 32 fluidounces = 0.9436 litre.  
 1 ton (Avoirdupois) = 2000 pounds = 907.2 kilogrammes.  
 1 yard = 3 feet = 36 inches = 0.9144 metre.

## GLOSSARY

**Abercrombie's Lotion:** Infusion of tobacco, 1 : 200.  
**A. C. E.:** Anæsthetic mixture of 1 of absolute alcohol, 2 of chloroform, and 3 of ether, all by volume.  
**Acid of Sugar:** Oxalic acid.  
**After-damp:** Carbon dioxide in mines following fire-damp explosions.  
**Alabastrine or Albocarbon:** Naphthalene.  
**Algaroth Powder:** Antimony oxychloride, SbOCl.  
**Alum:** Potassium aluminium sulphate.  
**Amidon:** Starch.  
**Ammonia Liniment:** Mixture of cotton-seed oil and ammonia water.  
**Antifebrin:** Acetanilid.  
**Apple-Oil:** Amyl valerianate,  $C_5H_{11}C_5H_9O_2$ .  
**Aqua Fortis:** Nitric acid.  
**Aqua Phagedænica:** Yellow lotion or wash.  
**Aqua Regia:** Nitrohydrochloric acid.  
**Aqua Sedativa:** Ammonia water, 2 ounces; spirit of camphor,  $1\frac{1}{2}$  drachms; sodium chloride, 1 ounce; water enough to make 1 pint.  
**Aqua Vitæ:** Brandy.  
**Aquila Alba:** An old name for calomel.  
**Argentum Vivum:** Native mercury.  
**Argols:** Deposits in wine casks containing cream of tartar.  
**Arsenic:**  $As_2O_3$ .  
**Art Metal:** An alloy of copper, tin, and lead.  
**Aspirin:** Acetyl-salicylic acid.  
**Astral Oil:** Kerosene.  
**Azote:** The French title for nitrogen.  
**Azotic Acid:** Nitric acid.  
  
**Baking Soda:** Sodium bicarbonate.  
**Baldwin's Phosphorus:** Calcium nitrate, when heated and exposed to sunlight, becomes luminous in the dark.  
**Balsam of Soap:** Soap Liniment.  
**Barilla:** Ashes of sea-plants.  
**Basham's Mixture:** Mixture of Iron and Ammonium Acetate.  
**Basilicon Ointment:** Resin Ointment.  
**Battley's Solution:** Liquor Opii Sedativus (50 per cent. laudanum).  
**Bay Rum:** Spirit of Myrcia.  
**Bell Metal:** An alloy of copper and tin.

- Bengal Fires:** Red:—Shellac, strontium nitrate, and powdered magnesium;  
Green:—Shellac, barium nitrate, and powdered magnesium.
- Benzol:** Benzene,  $C_6H_6$ .
- Benzolin:** Benzine, a petroleum product, mixture of  $C_6H_{12}$  and  $C_8H_{18}$ .
- Berthollet's Salt:** Potassium chlorate.
- Bestuchuf's Tincture:** An ethereal solution of ferric chloride.
- Bibron's Antidote:** (for rattlesnake poison) A solution of mercuric chloride, potassium iodide, bromine, alcohol, and water.
- Bitter Earth:** Magnesia.
- Bitter Salts:** Magnesium sulphate.
- Bittern:** The liquid remaining after the evaporation and crystallization of seawater in the manufacture of sodium chloride.
- Black Antimony:** Antimony trisulphide,  $Sb_2S_3$ .
- Black Draught:** Compound Infusion of Senna.
- Black Drop:** Vinegar of Opium.
- Black Lead:** Graphite.
- Black Wash:** A mixture of calomel and lime water. Mercurous oxide,  $Hg_2O$ , is formed.
- Blancard's Pills:** Pills of Ferrous Iodide.
- Blaud's Pills:** Pills of Ferrous Carbonate.
- Bleaching Powder:** A mixture of calcium hypochlorite and calcium chloride.
- Blondine:** Hydrogen dioxide, used for bleaching the hair.
- Blue Mass:** Mass of Mercury.
- Blue Ointment:** Mercurial ointment diluted with vaseline.
- Blue Pill:** Mass of Mercury.
- Blue Stone:** Copper sulphate.
- Blue Vitriol:** Copper sulphate.
- Bone Black:** Mixture of carbon and calcium phosphate.
- Bone Phosphate:** Tricalcium phosphate.
- Boracic Acid:** Boric acid.
- Borax:** Sodium tetraborate.
- Brandy:** Spiritus Vini Gallici.
- Brass:** An alloy of copper and zinc.
- Brimstone:** Roll sulphur.
- British Gum:** Dextrin manufactured by heating, under pressure, starch and water.
- Brown Mixture:** Compound Mixture of Glycyrrhiza (licorice).
- Burnett's Disinfecting Fluid:** A solution of zinc chloride.
- Burrow's Solution:** An aqueous solution of lead acetate, alum, and sodium sulphate.
- Butter of Antimony:** Antimony trichloride,  $SbCl_3$ .
- Butter of Paraffin:** Petrolatum or vaseline.
- Butter of Zinc:** Zinc chloride.
- Calamine:** Impure zinc carbonate.
- Calcimine:** A mixture for walls and ceilings, consisting of whiting, glue and water.
- Calcined Magnesia:** Magnesium oxide.
- Calomel:** Mercurous or Mild Chloride of Mercury.
- Calx:** Lime,  $CaO$ .
- Camphene:** Oil of turpentine.
- Canquoin's Paste:** A mixture of zinc chloride, native calcium sulphate and water.
- Caramel:** Burnt sugar.
- Carbinol:** Methyl alcohol.



- Carbonic Acid Gas:** Carbon dioxide.  
**Carron Oil:** Lime liniment.  
**Caustic Potash:** Potassium hydroxide.  
**Caustic Soda:** Sodium hydroxide.  
**Chalk:** Calcium carbonate.  
**Chalk Mixture:** A mixture of chalk, sugar, acacia and cinnamon water.  
**Chameleon Mineral:** Potassium permanganate or manganate.  
**Chili Saltpetre:** Sodium nitrate.  
**Chloric Ether:** An alcoholic solution of ethyl chloride,  $C_2H_5Cl$ .  
**Choke-damp:** A mixture of carbon monoxide and carbon dioxide in mines.  
**Churchill's Tincture of Iodine:** Compound Tincture of Iodine, N. F.  
**Citrine Ointment:** Ointment of Mercuric Nitrate.  
**Clemens's Solution:** A solution of potassium bromide and arsenate.  
**Club Moss:** Lycopodium.  
**Coal Oil:** Kerosene.  
**Coal-Tar Camphor:** Naphthalene.  
**Cologne Spirit:** Ethyl alcohol.  
**Colonial Spirit:** Methyl or wood alcohol.  
**Colophony:** Rosin.  
**Colothar:** Rouge,  $Fe_2O_3$ .  
**Columbian Spirit:** Methyl alcohol.  
**Common Salt:** Sodium chloride.  
**Compound Jalap Powder:** Mixture of jalap and cream of tartar.  
**Concentrated Lye:** An impure mixture of sodium carbonate and hydroxide.  
**Condy's Solution:** A solution of sodium permanganate.  
**Copperas:** Ferrous sulphate.  
**Corrosive Sublimate:** Mercuric chloride.  
**Cosmoline:** Vaseline.  
**Coster's Paste:** Contains two drachms of iodine to an ounce of tar.  
**Court Plaster:** Isinglass dissolved in water, alcohol and glycerin and spread on taffeta.  
**Cream of Tartar:** Potassium bitartrate.  
**Crédé's Ointment:** Colloidal silver, water, white wax and benzoated lard.  
**Crystals of Venus:** Cupric acetate,  $Cu(C_2H_3O_2)_2$ .  
**Cubic Nitre:** Sodium nitrate.
- Deshler's Salve:** Compound resin cerate.  
**De Valangin's Arsenical Solution:** Liquor Arsenici Hydrochloridi,  $AsCl_3$ .  
**Dewees's Carminative:** Mixture of Magnesia, Opium and Asafetida.  
**Diachylon Plaster:** Emplastrum Plumbi.  
**DoBell's Solution:** Compound Solution of Sodium Borate, N. F.  
**Donovan's Solution:** Solution of Arsenous and Mercuric Iodides.  
**Dover's Powder:** Powder of ipecac and opium.  
**Dutch Liquid:** Ethene dichloride,  $C_2H_4Cl_2$ .  
**Dutch Metal:** An alloy of copper and zinc.  
**Dutch White:** Impure white lead.
- Eagle Spirit:** Deodorized methyl alcohol.  
**Earth Wax:** Ozokerite, hard paraffin, fossil wax.  
**Eau de Javelle:** Solution of potassium hypochlorite.  
**Ehrlich's 606:** Paradiamidodioxarsenobenzol hydrochloride.  
**Elixir of Vitriol:** Aromatic Sulphuric Acid.  
**Embalming Fluids:** Contain: Arsenic, formalin, zinc chloride, hydrogen dioxide or sodium sulphite and usually glycerin.

**Emerald Green:** Copper arsenite,  $\text{CuHAsO}_3$ .  
**Emery:** A very hard variety of corundum (aluminium silicate).  
**English Salts:** Magnesium sulphate.  
**Epsom Salt:** Magnesium sulphate.  
**Eserine:** Physostigmine.  
**Essence of Vinegar:** Concentrated acetic acid.  
**Ethiops Mineral:** Black mercurous sulphide,  $\text{Hg}_2\text{S}$ .

**Ferrier's Snuff:** Compound bismuth powder.  
**Fire-damp:** Methane,  $\text{CH}_4$ .  
**Fixed Air:** Choke-damp,  $\text{CO}_2$  and  $\text{CO}$ .  
**Fixed Nitre:** Potassium carbonate.  
**Flake White:** Pure lead carbonate.  
**Flowers of Antimony:** Antimonous oxide,  $\text{Sb}_2\text{O}_3$ .  
**Flowers of Arsenic:** Arsenous oxide,  $\text{As}_2\text{O}_3$ .  
**Flowers of Benzoin:** Benzoic acid.  
**Flowers of Bismuth:** Bismuth oxide,  $\text{Bi}_2\text{O}_3$ .  
**Flowers of Sulphur:** Sublimed sulphur.  
**Flowers of Zinc:** Zinc oxide.  
**Fly Stone:** Cobalt glance, a mixture of cobalt and arsenic.  
**Foliated Earth of Tartar:** Potassium acetate.  
**Fool's Gold:** Iron pyrites,  $\text{FeS}_2$ .  
**Fowler's Solution:** Solution of Potassium Arsenite (1 per cent.).  
**Freezine:** Formaldehyde, used by dairymen as a milk preservative.  
**French Chalk:** Talc, chiefly magnesium silicate.  
**Friar's Balsam:** Compound Tincture of Benzoin.  
**Fruit Acid:** Citric acid.  
**Fuming Liquor of Libarius:** A solution of stannic chloride,  $\text{SnCl}_4$ .  
**Fusel Oil:** Amyl alcohol,  $\text{C}_5\text{H}_{11}\text{OH}$ .

**German Silver:** An alloy of copper, nickel, and zinc.  
**Glass of Antimony:** Fused antimony trisulphide,  $\text{Sb}_2\text{S}_3$ .  
**Glauber's Salt:** Sodium sulphate.  
**Glonoin:** Glyceryl trinitrate.  
**Glycoline:** Liquid vaseline.  
**Goddard's Drops:** Aromatic Spirit of Ammonia.  
**Goulard's Cerate:** Cerate of Lead Subacetate.  
**Goulard's Extract:** Solution of Lead Subacetate.  
**Grain Alcohol:** Ethyl alcohol.  
**Graphine:** Gas-carbon.  
**Gray Oil:** Calomel suspended in olive oil and lanolin.  
**Gray Powder:** Mercury with chalk (38 per cent. of mercury mixed with chalk and honey).  
**Green Precipitate:** Copper subacetate.  
**Green Vitriol:** Ferrous sulphate.  
**Gregory's Powder:** Compound Rhubarb Powder.  
**Gregory's Salt:** Double chloride of codeine and morphine.  
**Griffith's Mixture:** Compound Iron Mixture.  
**Gum Arabic:** Acacia.  
**Gypsum:** Native calcium sulphate.

**Hard Salt:** Powdered alum.  
**Harle's Solution:** Solution of Sodium Arsenite.  
**Hartshorn:** Ammonia.

- Heavy Carburetted Hydrogen:** Ethene,  $C_2H_4$ .  
**Heavy Earth:** Baryta or barium oxide,  $BaO$ .  
**Heberden's Ink:** Aromatic iron mixture.  
**Hiera Picra** or "**Hickery Pickery**": Aloes and Canella Powder.  
**Hive Syrup:** Compound Syrup of Squill.  
**Hoffmann's Anodyne:** Compound Spirit of Ether.  
**Holy Wood:** Guaiacum.  
**Honey Dew:** A mixture of cane-sugar, dextrin and invert sugar, exuded by a plant-sucker (Aphis).  
**Horse Salt:** Sodium sulphate.  
**Huxham's Tincture:** Compound Tincture of Cinchona.  
**Hypo:** Sodium thiosulphate.  
**Ice Vinegar:** Glacial acetic acid.  
**Iceland Moss:** Cetraria.  
**Ignis Fatuus:** "Will-o'-the-wisp," spontaneous combustion of phosphine,  $PH_3$ , generated in marshy places.  
**India or Chinese Ink:** Lamp-black mixed with gelatin and water and flavored with camphor and musk.  
**Indian Salt:** Cane-sugar.  
**Insect Flowers:** The flowers of Persian Pellitory.  
**Irish Moss:** Chondrus.  
**Iron Magma:** Ferric hydroxide.  
**Iron Pyrites:** Native sulphide of iron,  $FeS_2$ .  
**Italian Juice:** Licorice or glycyrrhiza.  
**Itch Ointment:** Compound Sulphur Ointment.  
**Ivory Black:** Bone-black or animal charcoal.  
**Jackson's Ammonia Lozenges:** Lozenges containing ammonium chloride, morphine hydrochloride, mucilages, flavor and sugar.  
**Jackson's Bathing Spirit:** An alcoholic solution of soap, camphor, and oil of rosemary and thyme.  
**Jackson's Pectoral Lozenges:** Lozenges containing sulphurated antimony, powdered ipecac, morphine hydrochloride, mucilages, flavor and sugar.  
**Jackson's Pectoral Syrup:** A syrup containing morphine hydrochloride, tolu and oil of sassafras.  
**James's Powder:** Antimonial powder (Oxide of antimony and calcium phosphate).  
**Japan Black:** A varnish consisting of asphalt, umber, turpentine and linseed oil.  
**Javelle Salt:** Potassium hypochlorite.  
**Javelle Water:** Solution of potassium hypochlorite.  
**Jesuit's Powder:** Powdered cinchona bark.  
**Judkin's Ointment:** An ointment containing lead acetate, lead oxide, sodium borate, oils of turpentine, olive and linseed.  
**Kalk:** Calcium oxide.  
**Kaolin:** Native aluminum silicate.  
**Kelp:** Ashes of sea-weed used in manufacture of iodine and sodium carbonate.  
**Kermes Mineral:** Sulphurated antimony, a mixture of antimony trisulphide,  $Sb_2S_3$ , and trioxide,  $Sb_2O_3$ .  
**King's Yellow:** Orpiment, arsenic trisulphide,  $As_2S_3$ .  
**Kitchener's Pills:** Rhubarb Pills.  
**Knight's Pills:** Pills of Aloes, Scammony and Gamboge.  
**Konseals:** Rice flour capsules.  
**Kyan's Disinfectant:** A solution of mercuric chloride.

- Labarraque's Solution:** Solution of Sodium Hypochlorite.
- Lac Sulphuris:** Precipitated sulphur.
- Lactin:** Lactose.
- Lady Webster's Pills:** Pills of Aloes and Mastic.
- La Fayette Mixture:** A mixture containing copaiba, spirit of nitrous ether, fluidextract of glycyrrhiza and solution of potassium hydroxide.
- Lana Philosophica:** Zinc oxide.
- Lapis Divinus:** A mixture of alum, saltpetre, copper sulphate and camphor.
- Lapis Infernalis:** Lunar caustic.
- Lapis Lazuli:** Native ultramarine, a dark-blue pigment.
- Latour's Chloride of Zinc Paste:** A paste made of zinc chloride, zinc nitrate and water.
- Laudanum:** Tincture of Opium.
- Laughing Gas:** Nitrous oxide,  $N_2O$ .
- Laveran's Solution:** A solution intended for injection, containing quinine hydrochloride, antipyrine and water.
- Laville's Gout Mixture:** A mixture containing quinine sulphate, cinchonine sulphate, extract of colocynth, diluted alcohol and red wine.
- Lead Water:** Diluted Solution of Lead Subacetate.
- Ledoyen's Disinfectant:** A mixture containing lead nitrate.
- Light Carburetted Hydrogen:** Methane,  $CH_4$ .
- Lightning Powder:** Lycopodium.
- Lime:** Calcium oxide.
- Lime Liniment:** A mixture of cotton-seed oil and lime water.
- Limestone:** Calcium carbonate.
- Liquid Alboline:** Liquid petrolatum or liquid vaseline.
- Lisle's Fever Powder:** Antimonial powder.
- Litharge:** Lead oxide,  $PbO$ .
- Liver of Sulphur:** A mixture of sulphides of potassium.
- Lodestone:** Native magnetic oxide of iron,  $Fe_3O_4$ .
- London Paste:** A depilatory consisting of lime and sodium hydroxide made into a paste with water.
- Lovi's Beads:** Glass beads used for determining the specific gravity of liquids.
- Lugol's Solution:** Compound solution of iodine (5 per cent. of iodine).
- Luna:** Ancient title for silver.
- Lunar Caustic:** Silver nitrate fused with potassium nitrate and moulded into pencils.
- Macquer's Salt:** Potassium arsenate.
- Magendie's Ethereal Tincture of Iodine:** A solution of iodine in ether.
- Magendie's Solution:** An aqueous solution containing 16 grains of morphine sulphate to the ounce.
- Magistery of Bismuth:** Bismuth subnitrate.
- Magnesia:** Magnesium oxide.
- Magnesia Alba:** Magnesium carbonate.
- Manhattan Spirit:** Methyl alcohol.
- Marble:** Calcium carbonate.
- Marguerite's Salt:** A mixture of potassium and sodium carbonates.
- Marine Acid:** Hydrochloric acid.
- Marsden's Paste:** A paste containing acacia, arsenic trioxide and water.
- Marsh Gas:** Methane,  $CH_4$ .
- Methylene Blue:** Methylthionine hydrochloride,  $C_{16}H_{18}N_3S$ .
- Michel's Paste:** A mixture of asbestos and concentrated sulphuric acid.
- Microcosmic Salt:** Sodium ammonium phosphate,  $NaNH_4HPO_4$ , found in the residue of evaporated stale urine of man.

- Milk of Asafœtida:** Emulsion of Asafœtida.  
**Milk of Bismuth:** A suspension of bismuth subnitrate in water.  
**Milk of Lime:** An aqueous mixture containing an excess of calcium hydroxide.  
**Milk of Magnesia:** Magnesium hydroxide suspended in water.  
**Milk of Sulphur:** Precipitated sulphur.  
**Mineral Blue:** Prussian blue,  $\text{Fe}_4(\text{Fe}(\text{CN})_6)_3$ .  
**Mineral Pitch:** Asphalt.  
**Minium:** Red lead,  $\text{Pb}_3\text{O}_4$ .  
**Mitigated Caustic:** Mitigated Silver Nitrate.  
**Monzel's Solution:** Solution of Ferric Subsulphate.  
**Mosaic Gold:** Stannic sulphide,  $\text{SnS}_2$ .  
**Moth Balls:** Naphthalene.  
**Mountain Blue:** Azurite, a native basic carbonate of copper.  
**Mountain Green:** Malachite, a native basic carbonate of copper.  
**Muriatic Acid:** Hydrochloric acid.  
**Music Metal:** An alloy of tin and antimony.  
  
**Natron:** Native sodium carbonate.  
**Neutral Mixture:** Solution of potassium citrate.  
**Nitre:** Saltpetre,  $\text{KNO}_3$ .  
  
**Oil of Smoke:** Creosote.  
**Oil of Sulphur:** Sulphuric acid.  
**Oil of Vitriol:** Sulphuric acid.  
**Olefiant Gas:** Ethene,  $\text{C}_2\text{H}_4$ .  
**Opodeldoc:** Camphorated Soap Liniment.  
**Oreide or French Gold:** An alloy of copper, zinc, and tin.  
**Orpiment:** Arsenic trisulphide,  $\text{As}_2\text{S}_3$ .  
**Oxidized Silver:** Silver coated with a thin layer of silver sulphide. This is usually accomplished by heating the silver with a solution of potassium sulphide.  
**Ozonized Ether:** A solution of hydrogen dioxide in ether.  
**Ozonized Water:** An aqueous solution of hydrogen dioxide.  
  
**Packfong:** German silver.  
**Palmer's Lotion:** A solution containing alum and mercuric chloride.  
**Palsy Drops:** Compound Tincture of Lavender.  
**Paradise Gas:** Nitrous oxide,  $\text{N}_2\text{O}$ .  
**Paraffin Wax:** Paraffin.  
**Paregoric:** Camphorated Tincture of Opium.  
**Paris Black:** Finely pulverized animal charcoal.  
**Paris Green:** Copper acetoarsenite,  $\text{Cu}(\text{C}_2\text{H}_3\text{O}_2)_3 \cdot 3\text{Cu}(\text{AsO}_2)_2$ .  
**Paris White:** Impure precipitated chalk.  
**Paris Yellow:** Lead chromate,  $\text{PbCrO}_4$ .  
**Pearl Ash:** Crude potassium carbonate.  
**Pearl Ointment:** Ointment of zinc oxide.  
**Pearl Powder or Pearl White:** Bismuth subnitrate or chloride, or zinc oxide.  
**Pearson's Salt:** Sodium arsenate,  $\text{Na}_2\text{AsO}_4$ .  
**Pectoral Powder:** Compound Licorice Powder.  
**Peroxide:** Hydrogen dioxide.  
**Petrolatum:** Vaseline.  
**Petroleum Ether:** Benzine (from Petroleum), a mixture of  $\text{C}_6\text{H}_{12}$  and  $\text{C}_8\text{H}_{18}$ .  
**Petroleum Jelly:** Vaseline.  
**Pewter:** An alloy of tin and lead and sometimes antimony.

- Phenacetin:** Acetphenetidin.  
**Phene:** Benzene,  $C_6H_6$ .  
**Phlogiston:** Hydrogen.  
**Phosgene Gas:** Carbonyl chloride,  $COCl_2$ .  
**Phosphine:**  $PH_3$ .  
**Picric Acid:** Trinitro-phenol,  $C_6H_3(NO_2)_3OH$ .  
**Pink Salt:** A mixture of stannic chloride and ammonium chloride.  
**Plasma:** Glycerite of Starch.  
**Plaster of Paris:** Exsiccated calcium sulphate.  
**Platinum Sponge:** Finely divided metallic platinum.  
**Plumbago:** Graphite, a native form of carbon.  
**Plummer's Pills:** Pills of Sulphurated Antimony and Calomel.  
**Poison Nut:** Nux Vomica.  
**Potash:** Impure potassium carbonate.  
**Potassa:** Potassium hydroxide.  
**Potato Oil:** Crude amyl alcohol.  
**Pot Metal:** An alloy of lead and copper.  
**Precipitatum per se:** Oxide of mercury,  $HgO$ .  
**Preservative:** A mixture of boric acid and borax.  
**Preserving Salts:** Sodium sulphite used by wholesale butchers to preserve meats.  
**Preston Salts:** The U. S. P. ammonium carbonate.  
**Prince's Powder:** Red mercuric oxide.  
**Printer's Ink:** A boiled linseed oil varnish containing a small amount of soap and lamp-black or other color.  
**Proof Spirit:** An old name applied to dilute alcohol, 50.8 per cent. by weight.  
**Proprietary Drops:** Compound Tincture of Aloes or of Myrrh.  
**Prussian Alkali:** Potassium ferrocyanide,  $K_4Fe(CN)_6$ .  
**Prussian Blue:** Ferric ferrocyanide,  $Fe_4(Fe(CN)_6)_3$ .  
**Prussian Brown:** Copper ferrocyanide,  $Cu_2Fe(CN)_6$ .  
**Prussiate of Potash (Red):** Potassium ferricyanide,  $K_3Fe(CN)_6$ .  
**Prussiate of Potash (Yellow):** Potassium ferrocyanide,  $K_4Fe(CN)_6$ .  
**Prussic Acid:** Hydrocyanic acid,  $HCN$ .  
**Pulvis Albus Romanis:** Magnesium carbonate.  
**Pulvis Purgans:** Compound Jalap Powder.  
**Punk:** Made by steeping a fungus in a solution of saltpetre and then drying.  
**Purgative Mineral Water:** Solution of Magnesium Citrate.  
**Putty:** A mixture of whiting and linseed oil.  
**Putty Powder:** A mixture of stannic oxide,  $SnO_2$ , and lead oxide,  $PbO$ .  
**Pyroglycerin:** Glyceryl trinitrate,  $C_3H_5(NO_2)_3$ .  
**Pyroxilic Spirit:** Methyl alcohol.  
**Pyroxylin:** Tetrannitro-cellulose,  $C_{12}H_{10}O_8(NO_2)_4$ .  
  
**Queen's Metal:** An alloy of tin, antimony, copper and zinc.  
**Quicklime:** Calcium oxide.  
**Quicksilver:** Metallic mercury.  
  
**Radical Vinegar:** Glacial acetic acid.  
**Ratsbane:** Arsenic, phosphorus, nux vomica.  
**Red Blister:** Ointment of Red Iodide of Mercury.  
**Red Borax:** Ferric oxide.  
**Red Cerate:** Calamine Cerate.  
**Red Crocus:** Ferric oxide.  
**Red Fire:** Shellac or sugar, potassium chlorate and strontium nitrate.

**Red Lead:**  $\text{Pb}_2\text{O}_3$ .

**Red Precipitate:** Red mercuric oxide.

**Red Tartar:** Argols.

**Regulus of Antimony:** Metallic antimony.

**Rex Magnus:** A mixture of boric acid and borax, used as a preservative.

**Rex Metallorum:** Gold.

**Ricord's Paste:** A caustic mixture of concentrated sulphuric acid and powdered carbon.

**Rochdale Salt:** Sodium tartrate.

**Rochelle Salt:** Potassium and sodium tartrate.

**Rock Oil:** Petroleum.

**Roll Turpentine:** A mixture of resin, yellow wax and lard.

**Roman Vitriol:** Copper sulphate.

**Ros:** Honey.

**Rose Pink:** Whiting colored with a decoction of Brazil wood and alum.

**Rouge (Animal):** Carmine and chalk.

**Rouge (Mineral):** Finely powdered ferric oxide.

**Rouge (Vegetable):** Carthamine and chalk.

**Rufus Pills:** Pills of Aloes and Myrrh.

**Rust:** Ferric oxide (also some hydroxide).

**Sacred Bark:** Cascara Sagrada bark.

**Sacred Elixir:** Compound Tincture of Rhubarb.

**Safety Oil:** Naphtha.

**Sal Absinthii:** Potassium carbonate.

**Sal Alembroth:** "Salt of Wisdom," a double chloride of mercury and the group  $\text{NH}_2$  :-  $\text{NH}_2\text{HgCl}$ .

**Sal Ammoniac:** Ammonium chloride.

**Sal Antihystericum:** Potassium acetate.

**Sal Catharticum:** Magnesium sulphate.

**Sal Chalybis:** Ferrous sulphate.

**Sal de Duobus:** Potassium sulphate.

**Sal Diureticus:** Potassium acetate.

**Sal Enixum:** Potassium bisulphate.

**Sal Febrifugum:** Potassium acetate.

**Sal Fossile:** Sodium chloride.

**Sal Marinum:** Sodium chloride.

**Sal Mirabile:** Sodium sulphate.

**Sal Perlatum:** Sodium phosphate.

**Sal Polychrest:** Potassium sulphate.

**Sal Prunelle:** Fused saltpetre, moulded into small balls for cattle.

**Sal Seignette:** Potassium and sodium tartrate.

**Sal Soda:** Impure sodium carbonate.

**Sal Vegetabile:** Potassium tartrate.

**Sal Volatile:** Ammonium carbonate.

**Saleratus:** Potassium bicarbonate.

**Salol:** Phenyl salicylate.

**Salt:** Sodium chloride.

**Salt Cake:** Sodium sulphate.

**Salt of Lemon:** Potassium binoxalate,  $\text{KHC}_2\text{O}_4$ , chiefly.

**Salt of Magnus:**  $\text{PtCl}_2 \cdot 2\text{NH}_3$ .

**Salt of Mars:** Ferrous sulphate.

**Salt of Phosphorus:** Microcosmic salt.

**Salt of Saturn:** Lead acetate.

- Salt of Sorrel:** Same as salt of lemon.  
**Salt of Steel:** Ferrous sulphate.  
**Salt of Tartar:** Potassium carbonate.  
**Salt of Wisdom:**  $\text{NH}_2\text{HgCl}$ .  
**Saltpetre:** Potassium nitrate.  
**Salts of Hartshorn:** Ammonium carbonate.  
**Saturn's Drops:** Solution of Lead Subacetate.  
**Scarlet Spirits:** A solution of stannous nitrate.  
**Scheele's Acid:** Diluted hydrocyanic acid.  
**Scheele's Green:** Copper arsenite,  $\text{CuHAsO}_3$ .  
**Schleich's Solution for General Anæsthesia:** A mixture of chloroform (30), ether (80), and benzine (15).  
**Schleich's Solution (No. 2) for Infiltration Anæsthesia:** Cocaine hydrochloride ( $1\frac{1}{2}$  gr.), morphine hydrochloride ( $\frac{1}{2}$  gr.), sodium chloride (3 gr.), distilled water ( $3\frac{1}{2}$  oz.).  
**Schlippe's Salt:** Sodium sulphantimoniate,  $\text{Na}_3\text{SbS}_4$ .  
**Schweinfurth Green:** Same as Paris green.  
**Scotch Magnesia:** Magnesium carbonate.  
**Scotch Soda:** Impure sodium carbonate.  
**Sedative Salt:** Boric acid.  
**Seidlitz Powder:** Compound Effervescing Powder: In white paper—tartaric acid, 35 gr.; in blue paper—Rochelle salt, 120 gr., and sodium bicarbonate, 40 gr.  
**Seignette Salt:** Rochelle salt.  
**Shepherd's Stone:** Bichloride of mercury.  
**Shoe Blackening:** A mixture of ivory black, molasses and sulphuric acid.  
**Shoemaker's Black:** Ferrous sulphate.  
**Silent Spirit:** Diluted rectified alcohol.  
**Silphine:** Asafetida.  
**Slaked Lime:** Calcium hydroxide, produced by adding water to lime.  
**Smalt:** Powdered glass colored blue with cobalt oxide.  
**Smelling Salts:** Chiefly ammonium carbonate.  
**Soda:** Sodium carbonate.  
**Soda Ash:** Crude sodium carbonate.  
**Soda Saltpetre:** Sodium nitrate.  
**Soda Water:** Water charged with 5 volumes of carbon dioxide under pressure.  
**Soldier's Ointment:** Ointment of mild chloride of mercury.  
**Soluble Glass:** Sodium silicate,  $\text{Na}_2\text{Si}_2\text{O}_5$ .  
**Soluble Gun-cotton:** Pyroxylin.  
**Soluble Tartar:** Potassium tartrate.  
**Sore Throat Balls:** Balls of potassium nitrate.  
**Sory Black:** Ferrous sulphate.  
**Speculum Metal:** An alloy of copper and tin.  
**Spelter:** An alloy of zinc and copper, or commercial zinc.  
**Spirit of Bones:** An impure ammonium carbonate.  
**Spirit of Chloric Ether:** Spirit of chloroform.  
**Spirit of Glonoin:** Spirit of Nitroglyceria.  
**Spirit of Hartshorn:** Alcoholic solution of ammonia; *i.e.*, spirit of ammonia.  
**Spirit of Mindererus:** Solution of Ammonium Acetate.  
**Spirit of Nitre:** Nitric acid.  
**Spirit of Salt:** Hydrochloric acid.  
**Spirit of Tartar:** Tartaric acid.  
**Spirit of Tin:** Stannic chloride,  $\text{SnCl}_4$ .  
**Spirit of Turpentine:** Oil of turpentine.



**Spirit of Vinegar:** Diluted acetic acid.

**Spirit of Wine:** Rectified alcohol.

**Spiritus Formicarium:** An alcoholic solution of formic acid.

**Spodium Steatite:** Zinc oxide.

**Spunk:** Same as Punk.

**Squibb's Mixture:** One ounce each of tincture of opium, tincture of capsicum and spirit of camphor, three drachms of chloroform, and alcohol to make five ounces.

**Steel Drops:** Tincture of Ferric Chloride.

**Steel Fat:** Ointment of calomel used to prevent rusting.

**Steel Powder:** Ferrous carbonate.

**Steel Wine:** Wine of iron.

**Stomachic Tincture:** Compound Tincture of Cardamom.

**Stone Black:** Animal charcoal.

**Stone Mercury:** Mercuric chloride.

**Strike:** Ammonia water.

**Stucco:** Calcium sulphate.

**Sugar of Lead:** Lead acetate.

**Sulphonal:** Sulphonmethane,  $(\text{CH}_3)_2\text{C}(\text{C}_2\text{H}_5\text{SO}_2)_2$ .

**Sulphurated Antimony:** A mixture of antimony trisulphide and trioxide used in vulcanizing rubber.

**Sulphurated Lime:** Calcium sulphide.

**Sulphuretted Hydrogen:** Hydrogen sulphide.

**Sulphuric Ether:** Ether,  $(\text{C}_2\text{H}_5)_2\text{O}$ .

**Surfeit Water:** Solution of ammonium acetate.

**Swedish Cholera Drops:** Compound Mixture of Opium and Ipecac.

**Swedish Green:** Copper arsenite,  $\text{CuHAsO}_4$ .

**Sweet Precipitate:** Mercuric chloride.

**Sweet Spirit of Nitre:** Spirit of nitrous ether.

**Table Salt:** Sodium chloride.

**Tar Balls:** Naphthalene.

**Tar Spirit:** Benzene,  $\text{C}_6\text{H}_6$ .

**Tartar Emetic:** Potassium antimony tartrate,  $\text{K}(\text{SbO})\text{C}_4\text{H}_4\text{O}_6$ .

**Tasteless Purging Salt:** Sodium phosphate.

**Tennant's Bleaching Powder:** Chlorinated lime.

**Terra Alba:** Kaolin.

**Tetronal:**  $(\text{C}_2\text{H}_5)_2\text{C}(\text{C}_2\text{H}_5\text{SO}_2)_2$ .

**Thenard's Blue:** A compound of the oxides of cobalt and aluminium.

**Thieves' Vinegar:** Aromatic acetic acid.

**Tin Liquor:** A solution of stannic chloride.

**Tin Salt:** Stannous chloride,  $\text{SnCl}_2$ .

**Tincal:** Native borax.

**Toothache Crystal:** Chloral hydrate.

**Toothache Ice:** Phenol and collodion.

**Toothache Powders:** Consist chiefly of prepared chalk.

**Torrington's Drops:** Compound tincture of benzoin.

**Trional:** Sulphonethylmethane,  $(\text{CH}_3)(\text{C}_2\text{H}_5)\text{C}(\text{C}_2\text{H}_5\text{SO}_2)_2$ .

**Trona:** Native sodium carbonate,  $\text{Na}_2\text{CO}_3$ .

**Trooper's Ointment:** Calomel ointment.

**Tully's Powder:** Compound Morphine Powder.

**Turnbull's Blue:** Ferrous ferricyanide,  $\text{Fe}_3(\text{Fe}(\text{CN})_6)_2$ .

**Turner's Cerate:** Calamine ointment.

**Turnsol:** Litmus.

**Turpeth Mineral:** Subsulphate of mercury,  $\text{HgSO}_4 \cdot 2\text{HgO}$ .

**Tutenag:** Zinc.

**Tutty:** Impure zinc oxide.

**Ultramarine:** A blue pigment composed of sodium sulphide and aluminum sodium silicate.

**Uction:** Calomel ointment.

**Urotropin:**  $(\text{CH}_2)_6\text{N}_4$ , hexamethylenamine.

**Usquebaugh:** Distilled and sweetened tinctures of mace, saffron, orange and citron peels.

**Valangin's Solution:** Solution of arsenic trioxide with hydrochloric acid.

**Vallet's Mass:** Mass of Ferrous Carbonate.

**Van Swieten's Liquor:** Solution of bichloride of mercury.

**Vareel:** Ash of sea-weeds.

**Vegetable Alkali:** Potassium hydroxide.

**Vegetable Black:** Finely pulverized wood charcoal.

**Vegetable Sulphur:** Lycopodium.

**Venetian Sublimate:** Mercuric chloride.

**Venua:** Ancient name for copper.

**Verdigris:** A mixture of basic copper acetates.

**Vermilion:** Artificial mercuric sulphide.

**Veronal:**  $(\text{C}_2\text{H}_5)_2\text{C}(\text{CO}-\text{NH})_2\text{CO}$ .

**Vienna Green:** Same as Schweinfurth green.

**Vienna Paste:** Potassium hydroxide with lime.

**Vinegar:** Diluted acetic acid.

**Vinegar Essence:** Concentrated acetic acid.

**Vinegar of Lead:** Solution of Lead Subacetate.

**Violet Powder:** Starch scented with orris root.

**Virgin Oil:** Olive oil.

**Virgin's Milk:** Solution of benzoin.

**Vitellus:** Yolk of egg.

**Vitrifiable Earth:** Silica.

**Vitriolic Acid:** Sulphuric acid.

**Volatile Alkali:** Ammonia.

**Volatile Liver of Sulphur:** Ammonium sulphide.

**Volatile Salt of Urine:** Ammonium carbonate.

**Volatile Salt of Vipers:** Ammonium carbonate.

**Vomiting Salt:** Zinc sulphate.

**Wade's Drops:** Compound Tincture of Benzoin.

**Warburg's Tincture:** Tinctura Antiperiodica.

**Ward's Paste:** Confection of Black Pepper.

**Warming Plaster:** Cantharidated tar plaster.

**Washing Blue:** Artificial ultramarine, or starch and indigo.

**Washing Soda:** Sodium carbonate.

**Water Glass:** Sodium silicate,  $\text{Na}_2\text{Si}_2\text{O}_5$ .

**Whiskey:** Spiritus Frumenti.

**White Acid:** A mixture of hydrofluoric acid and ammonium fluoride.

**White Arsenic:** Arsenic trioxide,  $\text{As}_2\text{O}_3$ .

**White Lead:** Basic lead carbonate,  $(\text{PbCO}_3)_2\text{Pb}(\text{OH})_2$ .

**White Precipitate:** Ammoniated mercury,  $\text{NH}_2\text{HgCl}$ .

**White Tartar:** Potassium bitartrate.

**White Vitriol:** Zinc sulphate.

**Whiting:** Impure precipitated chalk.

**Wine Stone:** Argols.

**Wonderful Salt:** Sodium phosphate.

**Wood Alcohol:** Methyl alcohol.

**Wood Creosote:** Creosote obtained from wood.

**Wood Spirit:** Methyl alcohol.

**Wood Vinegar:** Impure acetic acid.

**Wool Fat:** Lanolin.

**Yellow Ointment:** Ointment of Mercuric Nitrate.

**Yellow Metal:** Brass.

**Yellow Wash:** Made by adding mercuric chloride to lime water, mercuric oxide being formed.

**Zimmermann's Decoction:** A decoction of rhubarb, barley, and cream of tartar.

**Zinc Blende:** Native sulphide of zinc.

**Zinc Salve:** Ointment of Zinc Oxide.

**Zinc White:** Zinc Oxide.

**Zittmann's Decoction:** Compound Decoction of Sarsaparilla.

## PERCENTAGE SOLUTION TABLE

To prepare an aqueous solution of any desired percentage strength take

Grains of the substance to make a solution containing												Of water
1 in 5000	1 in 3000	1 in 1000	1 in 500	1 per cent.	1 per cent.	3 per cent.	5 per cent.	10 per cent.	20 per cent.	25 per cent.	50 per cent.	Fluid-ounces.
0.046	0.076	0.228	0.457	1.14	2.3	7.0	12.	25.3	57.	76.	228	1/2
0.091	0.152	0.456	0.913	2.29	4.6	14.1	24.	50.6	114.	152.	456	1
0.182	0.304	0.912	1.830	4.58	9.2	28.2	48.	101.3	228.	304.	912	2
0.547	0.912	2.740	5.480	13.75	27.6	84.6	144.	303.9	684.	912.	2736	6
0.729	1.220	3.650	7.310	18.32	36.8	112.8	192.	405.2	912.	1216.	3648	8
1.460	2.430	7.300	14.620	36.64	73.6	225.6	384.	810.4	1824.	2430.	7296	16

NOTE.—In using the above table it should be remembered that the full quantity of water designated must be taken. Example: 2 fluidounces of a 3 per cent. solution of silver nitrate are desired. Take 2 fluidounces of water and dissolve 28.2 grains of silver nitrate in it.

# INDEX

## A

Absinthin, 139  
 Absorption, 156  
 Acetanilid, 133, 204  
 Acetates, 127  
 Acetic acid, 122, 160, 200  
   diluted, 123  
   glacial, 123  
   test, 123  
   trichloroacetic acid, 123  
 Acetic ether, 115  
 Acetone, 121, 161  
 Acetphenetidin, 133  
 Acetylenes, 107  
 Acetyl-salicylic acid, 127  
 Acid salts, 42  
 Acidity of bases, 41, 42  
 Acids, 41, 62, 199  
   tests for common, 163, 164  
 Aconitine, 143  
 Acoustics, 29  
 Actinium, 50  
 Action of air on metals, 48  
 Adapters, 18  
 Adhesion, 8  
 Affinity, 34  
 Air, 11, 57  
 Albargin, 195  
 Alboline, 107  
 Albumin, 171  
   tests for, 166  
 Albuminometer, 171  
 Albumins, 149, 171  
 Alcohol, 113, 182, 199  
   absolute, 113, 182  
   denatured, 112, 113  
   diluted, 113, 114, 182  
   ethyl, 112  
   grain, 112  
   methyl, 112  
   wood, 112  
 Alcohols, 111  
 Aldehyde, acetic, 119  
   ethyl, 119  
   methyl, 119  
 Aldehydes, 112, 119  
 Ale, 180

Alkali group of metals, 48  
 Alkaline waters, 93  
 Alkalinity of blood, 167  
 Alkalies, 183  
 Alkaloids, 140  
   animal, 144  
 Alloys, 49, 50  
 Alum, 81  
   burnt, 81  
   dried, 81  
   exsiccated, 81  
 Aluminium, 49  
 Aluminium sulphate, 81  
 Amalgams, 50  
 Ammonia, 71, 158  
   aromatic spirit of, 71  
   spirit of, 71  
   stronger water, 71  
   test, 162, 164  
   water, 71  
 Ammonium, 71  
   benzoate, 129  
   bromide, 77  
   carbamate, 87  
   carbonate, 87  
   chloride, 75  
   compounds, 72  
   hydroxide, 71  
   iodide, 78  
   muriate, 75  
   salicylate, 129  
   test, 80, 162, 163  
 Ampère, 26  
 Amygdalin, 120, 139  
 Amyl nitrite, 117  
 Amylopsin, 156, 184  
 Amylum, 137  
 Animal cellulose, 136  
   charcoal, 60  
   fats, 118  
   ferments, 187  
   oils, 118  
   waxes, 118  
 Anode, 25  
 Antibodies, 185  
 Antifebrin, 133  
 Antimony, 49

**Antimony and potassium tartrate, 128**

Antipyrine, 134  
 Antiseptics, 188  
 Antizymotic, 188  
 Apomorphine hydrochloride, 142  
 Apothecaries' measure, 209  
     weight, 209  
 Approximate measures, 209  
 Aqua fortis, 48  
     regia, 48, 67  
 Arabinose, 136  
 Area, 3  
 Argols, 124  
 Argon, 57  
 Argyria, 84  
 Argyrol, 195  
 Aristol, 196  
 Arsenates, 68, 89  
 Arsenic, 49, 97, 157  
     acids, 68  
     group, 89  
     poisoning, 97  
     test, 90  
     trioxide, 97  
     white, 97  
 Arsenites, 68, 89  
 Arsenous acids, 68  
     iodide, 79  
     oxide, 97  
 Artificial silk, 138  
     oil of wintergreen, 116  
 Asbestos  
 Asepsis, 188  
 Aspirin, 127  
 Atmosphere, 11, 57  
 Atmospheric pressure, 12  
 Atom, 4, 37  
 Atomic weight, 37, 38  
 Atropine, 140  
 Auditory canal, 30  
 Autolysis, 155  
 Avogadro's law, 38  
 Avoirdupois weight, 209

**B**

Baking powders, 178  
     soda, 88  
 Barium, 82, 163, 165  
     test, 82  
 Barley sugar, 136  
 Barnstead still, 18  
 Barometer, 12  
 Bases, 41, 70  
     tests, 166

Basic salts, 42  
 Basicity of acids, 41  
 Baths, 17  
 Battery, 25  
 Beakers, 17  
 Beechwood creosote, 196  
 Beer, 180  
     bock, 180  
     lager, 180  
 Beet-sugar, 135  
 Benzaldehyde, 120  
 Benzene, 108  
     derivatives of, 133  
 Benzenes, 108  
 Benzin, 105  
 Benzoates, 129  
 Benzoic acid, 125, 201  
     test, 126  
 Benzol, 108  
 Benzolin, 105  
 Beta-oxybutyric acid, 160  
 Bicarbonates, 89  
     test, 89  
 Bichloride, 75  
     of mercury, 75  
 Bile, 156, 173  
     pigments, 156  
     salts, 156  
 Bilirubin, 162  
 Biliverdin, 162  
 Biniiodide of mercury, 79  
 Biology, 3  
 Bismuth, 49  
     citrate, 128  
     oxyiodide, 79  
     subnitrate, 84  
     subsaliolate, 129  
 Bitter almonds, oil of, 120  
     salt, 80  
 Biuret test, 167  
 Black bread, 178  
     lead, 61  
 Blaud's pills, 87  
 Bleaching powder, 197  
 Blood, 167, 173  
 Blue mass, 50  
     ointment, 50  
     pill, 50  
     stone, 81, 202  
     vitriol, 81, 202  
 Boiling point  
 Bone black, 61  
 Bone earth or mineral, 164  
     composition of, 164

Bone, 164  
     tests on, 165  
 Boracic acid, 69  
 Borates, 89  
     test, 89  
 Borax, 89  
     test, 89  
 Boric acid, 69, 200  
     test, 164  
 Boron, 60  
 Brandy, 113, 182  
 Brass, 49  
 Bread, 153  
 Brewing, 181  
 Brimstone, 58  
 British gum, 136  
 Brittleness, 6  
 Bromelin, 184  
 Bromides, 76, 77, 78  
     test, 78  
 Bromine, 55, 198  
 Bromism, 78  
 Bromoform, 111  
 Butane, 105  
 Butter fats, 118  
 Butterine, 118  
 Butyric acid, 123, 160

## C

Cadaverine, 144  
 Caffeine, 144  
 Calabar bean, 143  
 Calamine, 88  
 Calcination, 16  
 Calcined magnesia, 96  
 Calcium:  
     bromide, 77  
     carbonate, 88, 159  
     fluoride, 159  
     hydroxide, 72  
     hypochlorite, 76  
     hypophosphite, 86  
     oxide, 96  
     phosphate, 85  
     sulphate, 82, 159  
     sulphide, 82  
     test, 163  
 Calomel, 75  
 Calorie, 5  
 Calorific value table, 154  
 Calorimeter calorimetry, 15  
     Atwater, 16  
 Calx, 96  
 Camera, 21

Camphor, 203  
 Cane-sugar, 135, 136  
 Capillary phenomena, 8  
 Caramel, 136  
 Capric acid, 160  
 Caprylic acid, 160  
 Carbamid, 132  
 Carbazotic acid, 134  
 Carbinol, 112  
 Carbohydrates, 135, 151  
 Carbolated salve, 130  
 Carbolic acid, 44, 130, 190  
 Carbon, 60  
     compounds, 60, 61, 101  
     dioxide, 61, 95, 158  
     disulphide, 82  
     monoxide, 94  
     poisoning, 94  
     test, 101  
 Carbonated waters, 93  
 Carbonates, 86  
     test, 89, 163, 166  
 Carbonic acid, 68  
     test, 163  
 Carbonic acid gas, 95  
 Carbonization, 16  
 Carboxyl, 122  
 Cathode, 25  
 Caustic potash, 70  
     soda, 71  
 Cells, galvanic, 25, 26  
 Cellulase, 183  
 Cellulin, 136  
 Celluloid, 139  
 Cellulose, 136, 138  
 Cerebrin, 160  
 Chain series, 102  
 Chalk, 88  
     precipitated, 88  
     prepared, 88  
 Chalybeate waters, 93  
 Champagne, 180  
     artificial, 180  
 Changes, chemical, 3  
     physical, 33  
 Charcoal:  
     animal, 60  
     wood, 60  
 Chemical affinity, 34  
     changes, 33, 34  
     combinations, 48  
     composition of human body, 157  
 Chemical compounds, 33  
     elements, 35, 36

- Chemical equations, 40  
     formulae, 37  
     nomenclature, 44, 45  
     philosophy, 33  
     reactions, 46  
     symbols, 40  
 Chemistry, 35  
     inorganic, 31-46, 101  
     organic, 99-103  
     physiological, 147  
 Chili saltpetre, 83  
 Chloral, 120  
     hydrate, 120, 204  
 Chlorate of potash, 76  
     soda, 76  
 Chlorates, 76  
     test  
 Chloride of lime, 197  
 Chlorides, 74  
     test, 75  
     of mercury, 75  
 Chlorinated lime, 197  
     soda, 54  
 Chlorine, 54, 197  
 Chloroform, 110, 202  
 Choke-damp, 95  
 Choleic acid, 161  
 Cholesterin, 162  
 Cholic acid, 161  
 Choline, 162  
 Chromium, 49  
     trioxide, 203  
 Chymase, 185  
 Cider, 179  
 Cinchonine, 141  
 Citrates, 128  
 Citric acid, 125, 201  
     test, 125  
 Citrine ointment, 84  
 Cleaning oil, 107  
 Closed-chain series, 103  
 Cloves, oil of, 203  
 Coal, 61  
 Coal oil, 106  
 Coal-gas poisoning, 94, 95  
 Coal-tar creosote, 131, 196  
 Cobalt, 49  
 Cocaine, 141  
 Cocoa butter, 118  
 Codeine, 142  
 Cohesion, 8  
 Coke, 61  
 Cold, 14  
 Collagen, 153  
 Collodion, 139  
     cantharidal, 139  
     flexible, 139  
     styptic, 139  
 Colloids, 8  
 Color, 20  
     of metals, 47  
     of urine, 169  
     of water, 91  
 Combustion, 15, 16  
 Compass, 24  
 Compound iron mixture, 87  
 Compounds containing nitrogen, 132  
     of carbon, 60, 61  
 Composition of bone, 164.  
     of bone earth or mineral, 164  
     of gastric juice, 155  
     of human body, 157-168  
     of milk, 152  
     of proteins, 149  
     of saliva, 165  
     of urine, 169  
 Compressibility, 4  
 Condensers, 18  
 Conduction of electricity, 25  
 Conductors, 25  
 Coniine, 144  
 Conjugated proteins, 149  
 Cooking of foods, 153  
 Copper, 48  
     sulphate, 81, 202  
 Copperas, 81  
 Corpuscles, 167  
 Corrosive chloride of mercury, 75  
     sublimate, 75, 191  
 Cosmoline, 106  
 Cotton, 138  
     absorbent, 138  
     medicated, 138  
     mercerized, 138  
 Cream of tartar, 128  
 Creatine, 161  
 Creatinine, 161  
 Cremation, 158  
 Creolin, 196  
 Creosote, 131, 196  
     beechwood, 196  
     coal-tar, 131, 196  
     water, 131  
     wood, 131, 196  
 Cresol, 130, 196  
     compound solution of, 131  
 Cresylic acid, 130, 196  
 Crookes tube, 27

Crucibles, 16  
 Crystallization, 6  
     six systems of, 7  
 Crystalloids, 8  
 Crystals, 6  
     various systems, 6, 7  
 Cumene, 109  
 Cyanide of potassium, 90  
     of mercury, 192  
     poisoning, 192  
 Cyanides, 90  
 Cymogen, 105

**D**

Decoction, 11  
 Deflagration, 16  
 Deliquescence, 92  
 Denatured alcohol, 112, 113  
 Deodorants, 188  
 Desiccation, 19  
 Dextrins, 136  
 Dextrose, 13, 135, 159, 171  
 Diabetin, 135  
 Diacetic acid, 160  
 Diacetyl-morphine, 143  
 Diads, 39  
 Dialysis, 8  
 Dialyzer, 8, 9  
 Diamond, 61  
 Diastase, 183  
 Diethyl-malonyl-urea, 133  
 Diethylsulphon-dimethylmethane,  
     131  
     -methylethylmethane, 132  
 Diffusion, 8  
     of gases, 9, 11  
     of liquids, 8  
 Digallic acid, 126  
 Digestion, 10, 153, 155  
     gastric, 155  
     intestinal, 156  
     salivary, 155  
 Digitalin, 139  
 Dimethyl-ketone, 121  
 Dionin, 142  
 Disaccharides, 135  
 Disinfectants, 188  
 Distillation, 17, 181  
     destructive, 17  
     fractional, 17  
 Distilled water, 92  
 Distilling apparatus, 19  
 Divisibility, 3  
 Double salt, 81

Dry cell, 26  
 Drying oils, 118  
 Ductility, 6  
 Dynamite, 117

**E**

Ear, 30  
 Echo, 29  
 Effervescence, 95, 180  
 Effervescent sodium phosphate, 85  
 Efflorescence, 92  
 Elasticity, 4  
 Electric arc, 28  
     current, 24-26  
     energy, 28  
     units, 25, 26  
 Electricity, 24-28  
     chemical, 24, 25  
     frictional, 24  
     galvanic, 24  
     inductive, 24, 25  
     static, 24  
     thermal, 24, 26  
 Electrodes, 25  
 Electrolytic dissociation, 43, 44  
 Electromotive force, 26  
 Elements, 35  
     in human body, 157  
     table of chemical, 35, 36  
 Eleopten, 107  
 Emulsin, 120, 183  
 Energy, 4  
     kinetic, 4  
     potential, 4  
 Enzymes, 156, 183 ✓  
     animal, 183  
     vegetable, 183  
 Epsom salt, 80  
 Equations, chemical, 40  
 Equivalents, 210  
 Erepsin, 184  
 Eserine, 143  
 Esters, 115  
 Ethane, 105  
 Ether, 115, 202  
     acetic, 115  
     nitrous, 116  
     sulphuric, 115  
 Ethereal salts, 115  
 Ethers, 115  
 Ethyl alcohol, 112  
     bromide, 111  
 Ethyl chloride, 110  
     ether, 115



Ethyl nitrite, 116  
 oxide, 115  
 Ethylmorphine hydrochloride, 142  
 Eucalyptol, 108, 203, 204  
 Evaporating dishes, 16  
 Evaporation, 17  
 Expression, 40  
 Exsiccated sodium phosphate, 85  
 Exsiccation, 19  
 Extension, 3  
 Extraction of metals, 47  
 Extractive processes, 10  
 Eye, 22, 23

## F

Fat, 118  
 Fats and oils, 118  
   animal, 118, 151  
   body, 159  
 Fatty series, 105  
 Fehling's solution, 172  
   test, 172  
 Fellic acid, 161  
 Fermentation, 177-187  
 Ferments, 177-187  
   amylolytic, 183  
   coagulant, 183  
   glycolytic, 183  
   nitrifying, 186  
   organized, 183  
   proteolytic, 183  
   of putrefaction, 187  
   steatolytic, 183  
   unorganized, 183  
 Ferric hydroxide, 73  
   hypophosphite, 86  
   phosphate, 85  
   pyrophosphate, 85  
 Ferrous carbonate, 87  
   iodide, 79  
   sulphate, 81, 203  
 Fibrin, 167  
 Filter, Berkefeld, 9, 10  
   papers, 10  
 Filters, 9  
 Filtration, 9, 10  
 Fire-damp, 105  
 Flasks, 17  
 Fluorides, 64  
 Fluorine, 57, 198  
 Foodstuffs, 151  
   caloric values, 154  
   classification of, 151

Foodstuffs, cooking of, 153  
 Force, 4  
 Formaldehyde, 119, 193, 194  
 Formalin, 193, 194  
 Formates, 160  
 Formic acids, 122, 160  
 Formin, 132  
 Formose, 135  
 Fortification, 179  
 Formulæ, graphic, 37  
 Fowler's solution, 89  
 Frangulin, 139  
 Frictional electricity, 24  
 Fructose, 135  
 Fruit acid, 125  
 Funnels, 9, 10  
   hot-water, 9  
 Fusion, 15

## G

Galactose, 135  
 Gallates, 127  
 Gallic acid, 127  
   test, 127  
 Gallotannic acid, 126  
 Galvanic cells, 25  
   electricity, 24  
 Gas, illuminating poisoning, 94, 95  
 Gases, 11  
   of human body, 157  
 Gasolene, 105, 106  
 Gastric digestion, 155  
   juice, 155  
     composition of, 155, 156  
 German silver, 49, 50  
 Germicide, 188  
 Gin, 113, 182  
 Glauber's salt, 80  
 Globulins, 149  
 Glossary, 212  
 Glucose, 135, 136  
 Glucosides, 139  
 Gluten, 177  
 Glycerin, 114, 197  
 Glycyrrhizin, 139  
 Glycerol, 114  
 Glyceryl trinitrate, 116  
 Glycocholic acid, 161  
 Glycocoll, 161  
 Glycogen, 136, 139, 159  
 Glycoline, 107  
 Gold, 49  
 Goulard's extract, 96

Grain alcohol, 112  
     fermentation of, 181, 182  
 Grape-sugar, 135, 136  
 Graphite, 61  
 Gravitation, 5  
 Gray powder, 50  
 Green, Paris, 89  
     iodide of mercury, 78  
     Scheele's, 90  
     soap, 119  
     vegetables, 153  
     vitriol, 81  
 Griffith's mixture, 87  
 Group, alkali, 48  
     alkaline earths, 48  
 Gums, 136  
 Gun-cotton, 139  
     soluble, 138  
 Gutta-percha  
 Gypsum, 82

## H

Hæmoglobins, 167  
 Halogen acids, 162  
     salts, 74, 110  
 Halogens, 54, 197  
 Hardness, 6  
     of water, 91, 92  
 Heat, 14, 189  
     dry, 189, 190  
     moist, 189  
     sources of, 14  
 Helium, 36  
 Heller's test, 149  
 Heroin, 143  
 Hexamethylenamine, 132, 197  
 Hexamethylene tetramine, 132  
 Hexane, 106  
 Hippuric acid, 169  
 Histozyim, 185  
 Hoffmann's anodyne, 115  
 Homatropin, 141  
 Horse salt, 80  
 Human body, chemical composition  
     of, 157  
 Hydrargyrum, 75  
 Hydrastine, 143  
 Hydriodic acid, 64  
     test, 164  
 Hydrobromic acid, 63  
     test, 164  
 Hydrocarbons, 104  
     derivatives of 110, 122

Hydrochloric acid, 62  
     test, 163  
 Hydrocyanic acid, 68  
     poisoning, 68  
 Hydrogen, 51  
     dioxide, 91, 93, 158, 195  
     monoxide, 91  
     sulphide, 65, 158  
     test, 101  
 Hydrometer, 5, 6  
 Hydrofluoric acid, 64  
 Hydrosulphuric acid, 65  
     test, 163  
 Hydroxides, 71, 72  
 Hydroxyl, 71  
 Hygroscopic compounds, 92  
 Hyoscyamine, 141  
 Hypo, 83  
 Hypochlorites, 76  
 Hypophosphites, 86  
 Hypophosphorus acid, 67

## I

Ice, 15  
 Ignition, 15  
 Images, 19  
 Impenetrability, 4  
 Imperial measure, 209  
 Incandescent light, 28  
 Incineration, 16  
 Indestructibility, 3  
 Indican, 139, 173  
     test, 173  
 Indicators, 39  
 Indol, 161  
 Induction, 24  
     coil, 25  
 Inductive electricity, 24  
 Infusion, 10  
 Inorganic acids, 62  
     chemistry, 31-46, 101  
     compounds, 62  
     salts, 151  
 Inosit, 135, 159  
 Intestinal digestion, 156  
 Inulase, 183  
 Inulin, 136  
 Invertase, 184  
 Invertin, 184  
 Iodides, 78  
     test, 80  
     uses, 79  
 Iodine, 56, 198  
 Iodism, 80

Iodoform, 111, 196  
 Ionization, 43  
 Iron, 48  
   hydroxide, 73  
   magma, 73  
   pills, 87  
   test, 163  
 Isoamylamine, 144  
 Isomaltose, 135  
 Isovaleric acid, 160

## J

Jalapin, 139  
 Javelle water, 76

## K

Kalium, 36  
 Kerosene, 105, 106  
 Ketones, 112, 121  
 Kinetic energy, 5  
 Knockout drops, 120  
 Koumis, 182  
 Kreosote, 131  
 Kresol, 130  
 Krypton, 36

## L

Lactase, 183  
 Lactic acid, 123, 160, 201  
   bacilli, 201  
   test, 124  
 Lactometer, 6  
 Lactose, 135, 137, 159  
 Lactosin, 136  
 Lampblack, 61  
 Laudanum, 142  
 Laughing gas, 94  
 Lead, 49  
   acetate, 127  
   black, 61  
   monoxide, 96  
   oxide, 96  
   plaster, 96  
   sugar of, 127  
   water, 96  
 Lecithin, 160  
 Length, 3  
 Lenses, 20, 21  
 Leucin, 149  
 Leucocytes, 167  
 Levulin, 136  
 Levulose, 135  
 Lieberman's test, 150  
 Light, 19

Light, electric arc, 28  
   incandescent, 28  
   petroleum, 106  
 Lignin, 136  
 Ligroin, 105  
 Lime, 96, 202  
   milk of, 136  
   quicklime, 96  
   slaked, 72, 96, 202  
   stone, 88  
   sulphurated, 82  
   water, 96  
 Liquid measure, 209  
 Liquids, 7  
 Litharge, 96  
 Lithia waters, 93  
 Lithium, 129  
   benzoate, 129  
   bromide, 77  
   carbonate, 87  
   citrate, 128  
   salicylate, 129  
   test, 162  
 Litmus paper, 71, 162  
 Liver-dextrin, 139  
 Liver-starch, 136, 139  
 Lunar caustic, 84  
 Luminosity, 19  
 Lysol, 196

## M

Maceration, 10  
 Magnesia, 96  
   alba, 87  
   calcined, 96  
   milk of, 96  
 Magnesium, 49  
   carbonate, 87  
   citrate, 87  
   effervescing solution of, 87  
   hydroxide, 72  
   oxide, 96  
   sulphate, 80  
   test, 82, 163  
 Magnetic poles, 24  
 Magnetism, 24  
 Magnets, 24  
 Malleability, 6  
 Malt, 180  
 Maltase, 183  
 Malting, 180  
 Maltose, 135  
 Malt-sugar, 135  
 Manganese, 49

- Manganese, hypophosphite, 86  
     test, 163  
 Maple sugar, 135  
 Marble, 88  
 Mariner's compass, 24  
 Marsh gas, 105  
 Mash, 181  
 Mass, 3  
     of ferrous carbonate, 87  
 Matter, 3  
     conservation of, 3  
     indestructibility of, 4  
     states of, 4  
 Measures, 209  
 Meat, 153  
     proteins, 151  
 Mechanical mixtures, 33  
 Melanins, 162  
 Menstruum, 10  
 Menthol, 108, 203, 204  
 Mercerized cotton, 138  
 Mercurial ointment, 97  
 Mercuric compounds, 75  
     cyanide, 192  
     chloride, 75, 191  
     iodide, 79  
     nitrate, 84  
     ointment of, 84  
     solution of, 84  
     oxide, 97  
     test, 84  
 Mercurous compounds:  
     iodide, 78  
     chloride, 75  
 Mercury:  
     chloride, 75  
         corrosive, 75  
         mild, 75  
     iodide, 78  
         green, 78  
         mercuric, 75  
         mercurous, 75  
         red, 79  
         yellow, 78  
     oxide:  
         red, 97  
         yellow, 97  
     salicylate, 129  
     test, 167  
 Metallic oxides, 96  
 Metals, 47  
     alloys, 49, 50  
     amalgams, 50  
     atmospheric effects, 48  
     Metals, chemical properties, 48  
         extraction, 47  
         physical properties, 47  
         physiological effects, 50  
         sources, 47  
         specific gravity, 48  
         tests, 48, 162, 163, 166  
         uses, 48, 49  
     Metarsenite, 89  
     Methane, 105, 158  
     Methyl alcohol, 112  
         chloride, 110  
         salicylate, 116  
     Metric system, 210  
     Microscope, 20, 22  
     Mild chloride of mercury, 75  
     Milk, 152  
         fat, 152  
         cow's, 152  
         proteins, 152  
         sugar, 135  
         woman's 159  
     Mineral acids, 199  
         waters, 93  
         sperm oil, 118  
     Mirrors, 19  
     Mitigated caustic, 84, 195  
         silver nitrate, 84, 195  
     Molecular weight, 38  
     Molecules, 14  
     Monads, 39  
     Monkshood, 143  
     Monobasic acids, 112  
     Monosaccharides, 135  
     Morphine, 142  
     Moth balls, 205  
     Mother of vinegar, 186  
     Moulded silver nitrate, 84  
     Moulds, 186  
     Mucor mucedo, 180  
     Murexid tests, 171  
     Muriatic acid, 62  
     Muscle-sugar, 135, 159  
     Musical sound, 29, 30  
     Mycoderma aceti, 186  
     Myopsin, 156  
     Myronic acid, 139  
     N  
     Naphtha, 105, 106  
     Naphthalene, 109, 205  
     Neon, 11  
     Neurine, 145, 162  
     Neutralization, 41

Neutral salt, 42  
 Nickel, 49  
 Nicotine, 140  
 Nitrates, 84  
   test, 84, 163  
 Nitric acid, 48, 66  
   test, 163  
 Nitrifying ferments, 186  
 Nitrite, amyl, 117  
 Nitrites, 186  
 Nitro-salts, 83  
 Nitrocellulose, 138  
 Nitrogen, 57  
   acids, 66  
   monoxide, 94  
   test, 102  
 Nitroglycerin, 116  
 Nitrohydrochloric acid, 67  
 Nitrous acid, 66  
   ether, 116  
   oxide, 94  
 Nomenclature, chemical, 44, 45  
 Non-conductors, 25  
 Non-metallic oxides, 91  
 Non-metals, 51  
 Normal saline solution, 74  
   salt, 42  
 Nucleoproteins, 149  
 Nux vomica, 141

## O

Ohm, 26  
 Oidium albicans, 186  
 Oil of bergamot, 203  
   of birch, 203  
   bitter almonds, 120  
   of smoke, 131  
   of turpentine, 107  
     rectified, 108  
   of vitriol, 65  
   of wintergreen, 203  
 Oils, animal, 118  
   drying, 118  
   test, 164  
   vegetable, 118  
   volatile, 203  
 Ointment of zinc oxide, 97  
   of mercuric nitrate, 84  
 Olefins, 107  
 Oleic acids, 160  
 Oleomargarine, 118  
 Open-chain series, 102  
 Opium, 142

Organic acids, 122  
   chemistry, 99-103  
   salts, 127  
 Orthophosphoric acid, 67  
 Ossein, 165  
   test, 165  
 Ovens, 16  
 Oxalic acid, 124, 160  
   test, 124, 164  
 Oxidation, 46, 53  
 Oxides, 91, 96, 97  
   metallic, 96  
   non-metallic, 97  
   of hydrogen, 91  
   of mercury, 97  
 Oxybenzoic acid  
 Oxygen, 63, 188  
 Ozone, 54

## P

Palm sugar, 135  
 Palmitic acid, 160  
 Pancreatic juice, 156  
   composition of, 156  
 Pancreatin, 184  
 Papain, 183  
 Paper, parchment, 138  
 Paraffin, 105, 107  
   wax, 107  
 Paraffins, 105  
 Paraformaldehyde, 119  
 Paraldehyde, 119  
 Parchment paper, 138  
 Paregoric, 142  
 Paris green, 89  
   white, 88  
 Pectin-sugar, 183  
 Pearl ash, 86  
 Pectinase, 183  
 Pepsin, 184  
 Pepsinogen, 184  
 Peptids, 155  
 Peptones, 155  
 Percentage solution table, 224  
 Percolation, 11  
 Percolators, 10  
 Permanganate of potash, 90, 192  
 Permanganates, 90  
   test, 90  
 Peroxide of hydrogen, 93  
 Perry, 179  
 Petrolatum, 105, 106, 107  
 Petroleum, 105, 205

- Petroleum, crude, 105  
     ether, 105  
     jelly, 106  
     pitch, 205  
 Phenacetine, 133  
 Phenol, 130, 161, 190  
     liquefied, 130  
     ointment, 130  
 Phenols, 130  
 Phene, 108  
 Phenyl salicylate, 117  
 Phenylacetamid, 133  
 Phosphate of soda, 85  
 Phosphates, 85  
     test, 163  
 Phosphoproteins, 149  
 Phosphorescence, 59  
 Phosphoric acid, 67  
     test, 102, 163  
 Phosphorus, 59  
     acids, 67  
     red, 59  
     yellow, 59  
 Phospho-salts, 85  
 Physical changes, 33  
     properties of metals, 47  
 Physics, 3  
 Physiological effects of metals, 50  
 Physostigmine, 143  
 Picric acid, 134  
 Pigments of bile, 173  
 Piles, electric, 26  
 Pills of ferrous carbonate, 87  
 Pilocarpine, 140  
 Plant fibre, 138  
 Plasma, 167  
 Plaster of Paris, 82  
 Platinum, 49  
 Plumbago, 61  
 Polariscopes, 20  
 Poles, magnetic, 24  
 Polonium, 50  
 Polysaccharides, 135  
 Pores, 168  
 Porosity, 4  
 Porter, 180  
 Potable water, 92  
 Potash, 86  
     prussiate of, 90  
 Potassium:  
     acetate, 127  
     acid tartrate, 128  
     aluminium sulphate, 81  
     arsenite, 89  
     Potassium arsenite, solution of, 89  
         bicarbonate, 89  
         bitartrate, 128  
         bromide, 77  
         carbonate, 86, 159  
         chlorate, 76  
         chloride, 74, 158  
         citrate, 128  
         cyanide, 90  
         hydrate, 70  
         hydroxide, 70  
         hypochlorite, 76  
         hypophosphite, 86  
         iodide, 78  
         nitrate, 83  
         permanganate, 90, 192  
         phosphate, 86  
         sodium tartrate, 128  
         sulphate, 159  
         test, 89  
     Precipitated calcium carbonate, 88  
         zinc carbonate, 88  
 Pressure of atmosphere, 11, 12  
 Prism, 20  
 Prismatic spectrum, 23  
 Propane, 105  
 Propenyl hydroxide, 114  
 Properties of gases, 11  
     of liquids, 7  
     of solids, 6  
 Propionic acid, 160  
 Propyl hydroxide, 70  
 Protagon, 160  
 Protargol, 195  
 Proteins, 149  
     analyses of, 149  
     classification of, 149  
     conjugated, 149  
     derived, 149  
     simple, 149  
     tests for, 149, 150, 162  
 Proteoses, 149  
 Protiodide of mercury, 78  
 Prussiate of potash, 90  
     red, 90  
     yellow, 90  
 Prussic acid, 68, 93  
     poisoning, 93  
 Ptomaines, 140, 144, 188  
 Ptyalin, 155, 184  
     test, 166  
 Putrefying ferments, 158  
 Pyroglycerin, 116

Pyrophosphates, 85  
Pyroxylin, 138

## Q

Quantity of urine, 169  
Quicklime, 96  
Quinine, 141, 204

## R

Radicals, 4  
Radio-active metals, 50  
Radium, 50  
Raffinose, 136  
Rain water, 92  
Rays, 19  
Reactions, 34  
    analytic, 34  
    chemical, 34  
    synthetic, 34  
Receivers, 18  
Red mercuric iodide, 79  
Reduction, 46  
Reflection, 20  
Refraction, 20, 21  
Rennin, 185  
Residues, 16  
Resins, 61, 121  
Resonance, 29  
Resorcin, 131, 204  
Resorcinol, 131  
Retina, 23  
Retorts, 18  
Roasting, 16  
Rochelle salt, 128  
Röntgen rays, 27  
Rubber, 166  
Rum, 182  
Rusting, 48  
Rutic acid, 160

## S

Saccharase, 183  
Saccharated ferrous carbonate, 87  
Saccharometer, 172  
Saccharum lactis, 137  
Safety oil, 106  
Sal ammoniac, 75  
Salicin, 139  
Salicylates, 129  
Salicylic acid, 126, 201  
    test, 126  
Saliva, 155, 165, 166  
    composition of, 166  
    examination of, 166

Salivary digestion, 155

Salol, 117

Sal seignette, 128

    soda, 86

    volatile, 87

Salt, acid, 74

    basic, 42, 74

    common, 74

    double, 42, 81

    Epsom, 80

    Glauber's, 80

    horse, 80

    neutral, 42

    normal, 42

    solution, 74

    Rochelle, 128

    table, 74

Saltpetre, 83

    Chili, 83

Salts, 41, 50, 74

    acid, 41

    basic, 41

    double, 41

    ethereal, 115

    halogen, 74, 110

    inorganic

    normal or neutral, 41, 42

    of tartar, 86

    organic

Salvarsan, 134

Salve, carbolated, 130

    zinc, 197

Santonin, 139

Saponification, 119

Saponin, 139

Sarcolactic acid, 160

Scheele's green, 90

Science, 3

Sea-water, 93

Serum, 167

Signal Service barometer, 12

Silica, 159

Silicon, 60

Silver, 49

    mitigated, 195

    moulded, 195

    nitrate, 84, 195

Simple sugars, 135

Siphon, 13

    barometer, 12

Skatol, 161

Slaked lime, 72

Soap:

    carbolated solution, 190

    green, 119

- Soap, hard, 119  
     soft, 119  
 Soaps, 119, 199  
 Soda, 88  
     baking, 88  
     washing, 86  
     water, 95  
 Sodium acetate, 127  
     acid sulphite, 80  
     arsenate, 89  
         dried, 89  
         exsiccated, 89  
         solution of, 89  
     benzoate, 129  
     bicarbonate, 88  
     bisulphite, 80  
     borate, 89  
     bromide, 76  
     carbonate, 86, 159  
     chlorate, 76  
     chloride, 74, 158  
     citrate, 128  
     hydrate, 71  
     hydroxide, 71  
     hypochlorite, 76  
     hypophosphite, 86  
     hyposulphite, 83  
     iodide, 78  
     nitrate, 83  
     phosphate, 85  
     pyrophosphate, 86  
     sulphate, 80, 159  
     salicylate, 129  
     tetraborate, 89  
     thiosulphate, 83  
     test, 162  
 Solder, 49  
 Solids, 6  
     properties of, 6  
 Soluble ferric phosphate, 58  
     pyrophosphate, 85  
 Solution, 9  
     percentage (table), 224  
     saturated, 9  
     normal salt, 42  
 Solutol, 196  
 Solvents, 9  
 Sorghum, 135  
 Sound, 29  
     musical, 29  
     wave-motion, 29  
 Sources of heat, 14  
     of metals, 47  
 Sparteine, 144  
 Specific gravity, 5  
     of metals, 48  
         of urine, 169  
         weight, 5  
 Spectroscope, 20  
 Spectrum, prismatic, 20, 23  
 Spirit of ether, 115  
     compound, 115  
     of glonoin, 116  
     of nitroglycerin, 116  
     of nitrous ether, 116  
     of turpentine, 107  
     of wine, 112  
     of wintergreen, 116  
 Spiritus formicarium, 122  
     frumenti, 113  
     vini gallici, 113  
 Sprays, 204  
 Starch, 136, 137  
     liver, 159  
     sugar, 135  
 States of matter, 4  
 Static electricity, 24  
 Steapsin, 156, 184  
 Stearic acid, 160  
 Stearopten, 107, 203  
 Sterilization, 189, 190, 194  
 Stills, 18, 19  
 Stout, 180  
 Strontium:  
     bromide, 77  
     salicylate, 129  
     test, 78  
 Strophanthin, 139  
 Strychnine, 141  
 Sublimate, 18  
     corrosive, 75, 191  
 Sublimation, 18  
 Succus entericus, 156  
 Sucrose, 135, 136  
 Sugar, 135  
     barley, 136  
     beet, 135  
     cane, 135, 136  
     dextrose, 135, 136  
     formose, 135  
     fructose, 135  
     galactose, 135  
     glucose, 135  
     grape, 135, 136  
     in urine  
     inosit, 135  
     lactose, 135  
     levulose, 135  
     malt, 135  
     milk, 135, 137



Sugar, maple, 135  
 muscle, 135, 155  
 of lead, 127  
 palm, 135  
 pectin, 183  
 saccharum, 136  
 sorghum, 135  
 starch, 135  
 sucrose, 136  
 wood, 136  
 Sugars, 135  
   complex, 135  
   simple, 135  
 Sulphates, 80  
   test, 82  
 Sulphides, 82  
 Sulphites, 80  
 Sulphonal, 131  
 Sulphonethylmethane, 132  
 Sulphonmethane, 131  
 Sulpho-salts, 80  
 Sulphur, 58  
   acids, 64  
   derivatives, 131  
   dioxide, 94  
   precipitated, 59  
   rolled, 58  
   sublimed, 59  
   test, 165  
   washed, 59  
 Sulphurated lime, 82  
 Sulphuretted hydrogen, 65  
 Sulphur waters, 93  
 Sulphuric acid, 65  
   test, 102, 163  
   ether, 115  
 Sulphurous acid, 64, 199  
 Sweat, 168  
 Sweet spirit of nitre, 116  
 Symbols, 35-37

## T

Tannic acid, 126, 202  
   test, 126  
 Tannin, 126  
 Tar, test, 164  
 Tartar emetic, 128  
 Tartaric acid, 124, 201  
   test, 125  
 Tartrates, 128  
 Taurine, 162  
 Temperature, measurement of, 15  
 Tenacity, 6  
 Terpenes, 107  
 Terpin hydrate, 203

Tests for common acids, 163, 164, 165  
   for common metals, 162, 163  
 Tetanine, 145  
 Tetronal, 132  
 Thermal electricity, 26  
   units, 25, 26  
 Thermometers, 14, 15  
   Centigrade, 15  
   Celsius, 15  
   clinical, 15  
   Fahrenheit, 15  
   Réaumur, 15  
 Thiosulphates, 83  
 Thorium, 50  
 Thymol, 108, 203, 204  
 Tin, 48, 49  
 Tincture of iodine, 56  
   press, 10  
 Toluene, 109  
 Torrefaction, 16  
 Translucent bodies, 19  
 Triads, 39  
 Triatomic alcohol, 114  
 Trichloracetic acid, 123  
 Trichloraldehyde, 120  
 Trinitro-phenol, 133  
 Trional, 132  
 Troy weight, 205  
 Trypsin, 156, 184  
 Tunicin, 136  
 Tuning fork, 29  
 Turpentine, 107, 108  
   oil of, 107, 203  
   rectified oil of, 108  
   spirit of, 107  
 Type-metal, 49  
 Tyrosine, 161  
 Tyrotoxicon, 145

## U

Urea, 101, 132, 161, 162, 170 ✓  
   diethyl-malonyl, 133  
 Ureometer, 170  
 Urotropine, 132  
 Uric acid, 160  
   tests, 167  
 Uricometer, 171  
 Urine, 169  
   analysis of, 169  
   examination of, 170  
   specific gravity of, 169  
 Uses of metals, 48, 49

## V

Valence, 38, 39  
 Vallet's mass, 87

Vapor, 17  
 Vaporization, 17  
 Vaseline, 106  
   carbulated, 130  
   liquid, 107  
   white, 106  
 Vegetable oils, 118  
   green, 153  
 Ventilation, 11  
 Veratrine, 143  
 Veronal, 133  
 Vinegar, 123  
   aromatic, 200  
   mother of, 186  
 Vinum album, 113  
   rubum, 114  
 Viscose, 138  
 Vision, 22, 23  
 Vital force, 101  
 Volatile oils, 107, 203  
 Volt, 25  
 Voltmeter, 27  
 Volume, 3

## W

Washing soda, 86  
 Water, 91, 151, 158  
   alkaline, 93  
   baths, 17  
   carbonated, 93  
   chalybeate, 92  
   distilled, 92  
   filtered, 9  
   hardness of, 91  
     permanent, 92  
     temporary, 91  
   lead, 96  
   lithia, 93  
   mineral, 93  
   of crystallization, 91, 92  
   potable, 92  
   rain, 92  
   saline, 93  
   sea, 92  
   sulphur, 93  
   test, 164  
   unfiltered, 9  
   vapor, 17  
 Watt, 26  
 Waxes, animal, 118  
 Weight, 37, 38  
   apothecaries', 209  
   atomic, 37, 38  
   avoirdupois, 209

Weight, metric, 210  
   molecular, 38  
   Troy, 209  
 Weights and measures, 209  
 Whiskey, 113, 181  
   artificial, 182  
 White arsenic, 97  
   lead,  
     of egg, 75, 149, 151, 154, 192  
     Paris, 88  
   vitriol, 81  
   wine, 113  
 Whiting, 88  
 Wine, 114, 179  
   red, 114  
   white, 113  
 Wines, 114  
   dry, 114  
   sparkling, 114  
   still, 114  
   sweet, 114  
 Wintergreen, artificial oil of, 116  
 Wood alcohol, 112  
   charcoal, 60  
   creosote, 131, 196  
   silk, 139  
   spirits, 112  
   sugar, 136  
 Work, muscular, 159

## X

Xanthoproteic test, 150  
 X-rays, 27  
 Xenon  
 Xylene, 109  
 Xylose, 138

## Y

Yeast, 185, 186  
 Yellow mercurous iodide, 78

## Z

Zinc, 49  
   acetate, 127  
   bromide, 77  
   carbonate, 88  
   chloride,  
   oxide, 97  
     ointment, 97  
     salve, 97  
   phenolsulphonate, 202  
   poisoning, 82  
   sulphate, 81  
 Zymase, 183, 184





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